

- [54] **AUTOMATIC PIPETTING APPARATUS**
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- [73] **Assignee:** Helena Laboratories Corporation, Beaumont, Tex.
- [21] **Appl. No.:** 89,025
- [22] **Filed:** Aug. 24, 1987

- 4,503,011 3/1985 Hubeau ..... 422/102
- 4,554,839 11/1985 Hewett et al. .... 73/863.32
- 4,578,169 3/1986 Vicario et al. .... 204/182.7

**FOREIGN PATENT DOCUMENTS**

- 0097655 6/1983 Japan ..... 422/70

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**Related U.S. Application Data**

- [63] Continuation of Ser. No. 853,201, Apr. 17, 1986, abandoned.
- [51] **Int. Cl.<sup>4</sup>** ..... B01L 3/02
- [52] **U.S. Cl.** ..... 73/864.21; 204/299 R; 422/102; 422/70; 210/198.3
- [58] **Field of Search** ..... 73/863.31, 863.32, 863.01, 73/863.33, 864.21; 204/299 R, 182.7, 182.8, 182.9; 422/102, 62, 69, 70, 55, 100, 56, 68.02, 68.08, 63, 67; 436/169; 210/198.3, 658; 435/815

**References Cited**

**U.S. PATENT DOCUMENTS**

- 3,266,554 8/1966 Brownrigg ..... 210/198.3
- 3,536,449 10/1970 Astle ..... 73/863.32
- 3,585,129 6/1971 Delfel ..... 210/198.3
- 3,616,387 10/1971 Siebert et al. .... 204/299 R
- 3,902,852 9/1975 Lemieux et al. .... 73/863.32
- 3,915,856 10/1975 Meyer ..... 210/198.3
- 4,004,548 1/1977 Smola et al. .... 210/198.3
- 4,166,766 9/1979 Metzberg et al. .... 435/815
- 4,264,327 4/1981 Blum ..... 422/82
- 4,272,381 6/1981 Kremer et al. .... 422/70
- 4,375,401 3/1983 Catsimpoolas ..... 204/299 R
- 4,478,094 10/1984 Salomaa et al. .... 73/863.32
- 4,494,403 1/1985 Bowers et al. .... 73/863.58

[57] **ABSTRACT**

An automatic pipetting apparatus is disclosed having a base on which is mounted a vertical frame supporting a row of positive displacement pipettes which are driven in the up or down direction by an electromechanical mechanism under microprocessor controls. The apparatus includes a base, a track and a carriage longitudinally movable beneath the row of pipettes. The carriage includes an independent translating and position signal generation mechanism. The carriage carries a tray which includes sample chambers, a space to receive a microporous electrophoresis support medium, such as a cellulose acetate strip, a wash well, rinse well and a space to receive blotting paper. The pipettes include a barrel and a plunger capable of aspirating and dispensing from 0.5 to 5  $\mu$ l of liquid. The barrels move up and down with respect to the base by means of another independent translating and signal generating mechanism. The barrels may be easily replaced from the mechanism if they become damaged or worn from many operating cycles. The apparatus under microprocessor program control, washes, rinses, blots the barrels before and after each application or engagement of the barrels with a liquid or contaminant.

**32 Claims, 10 Drawing Sheets**

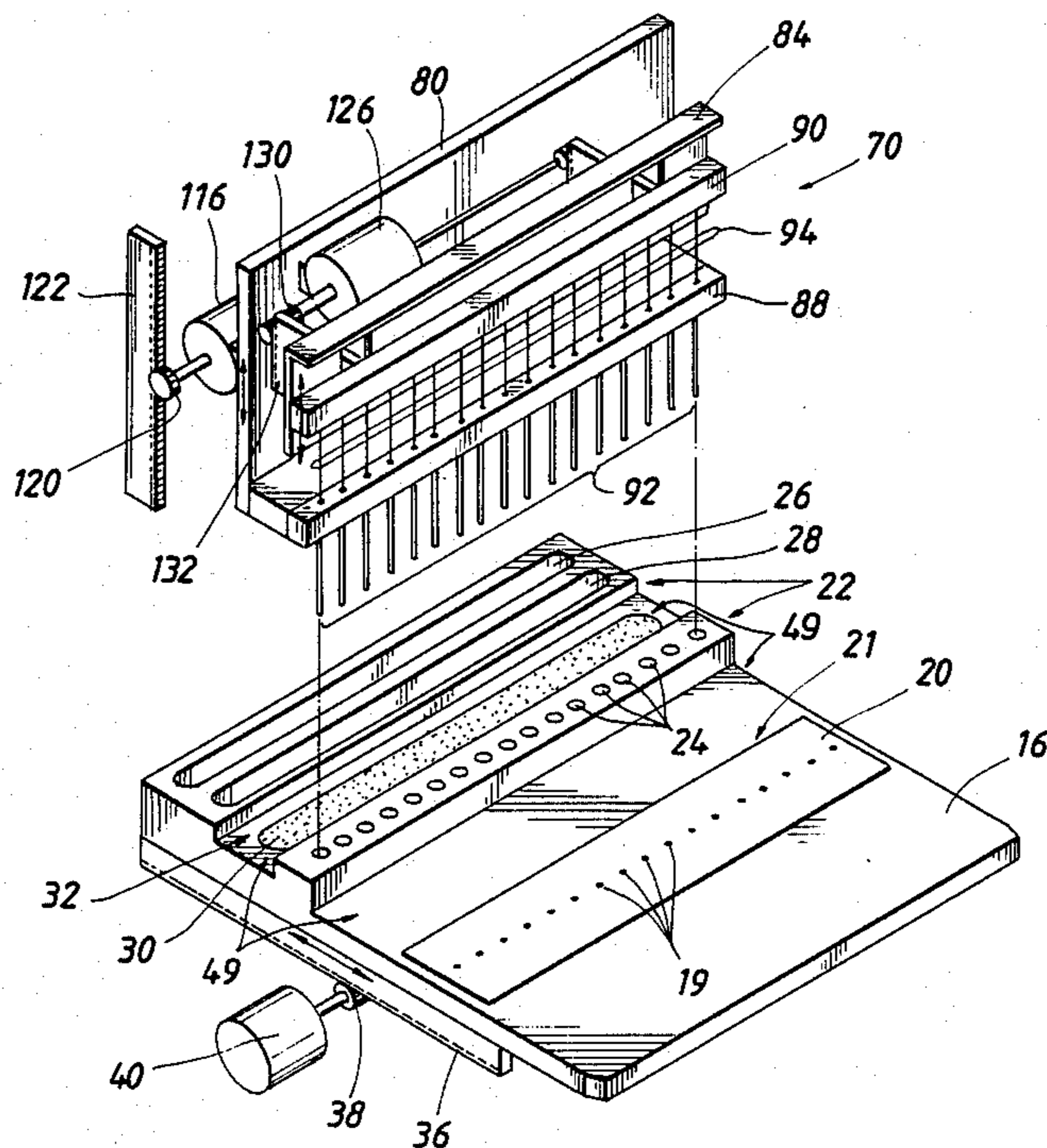


FIG. 1

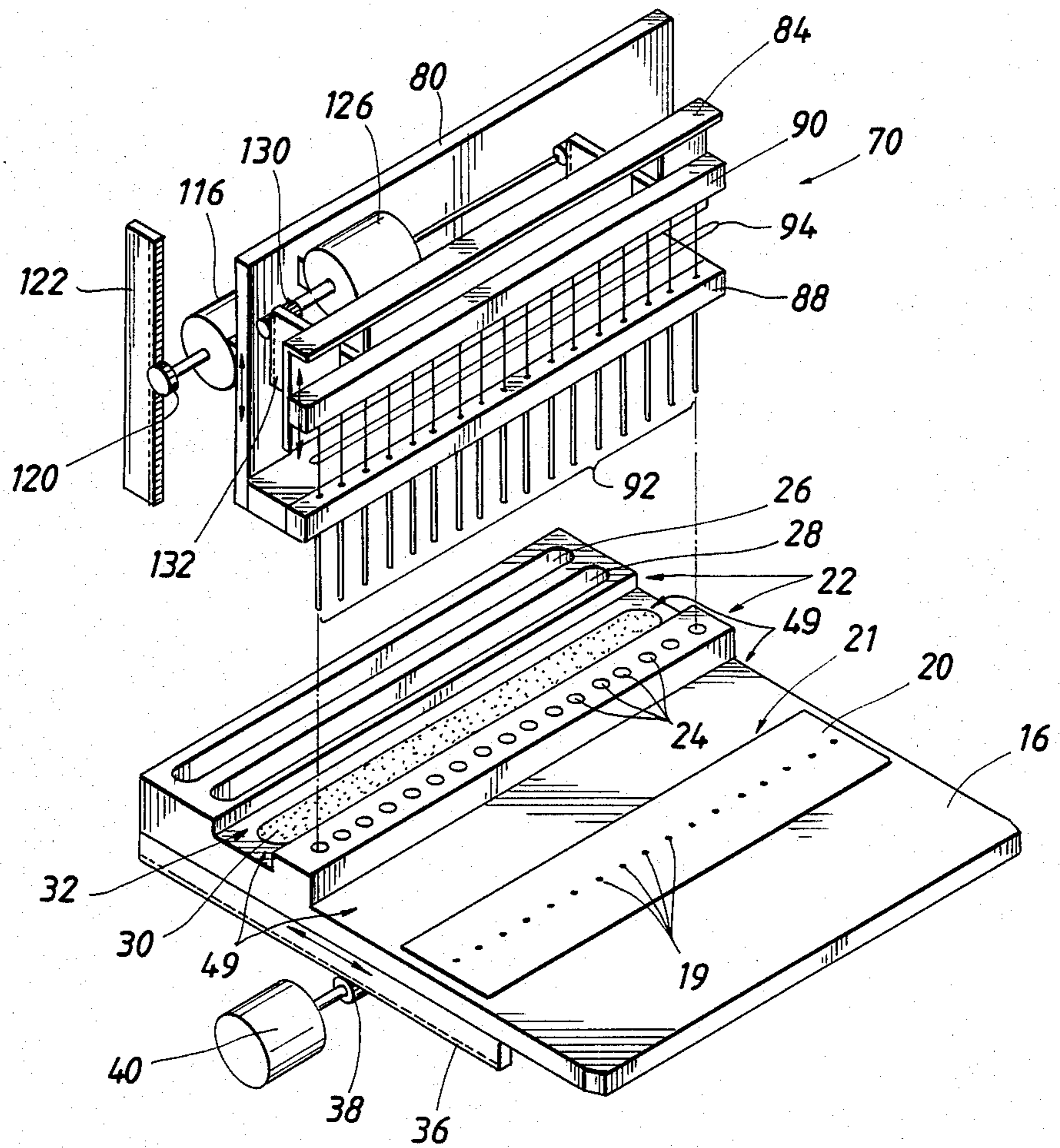
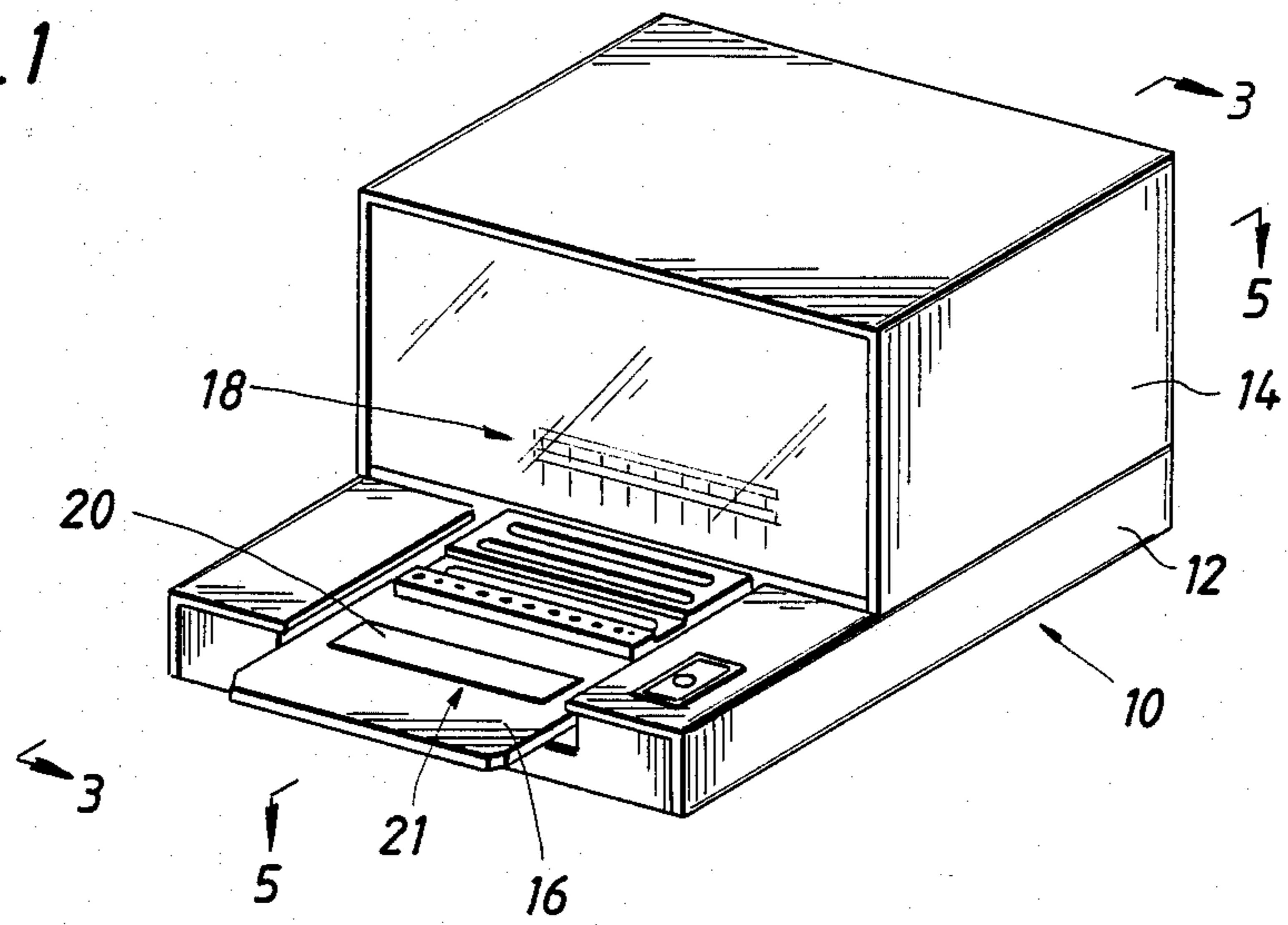
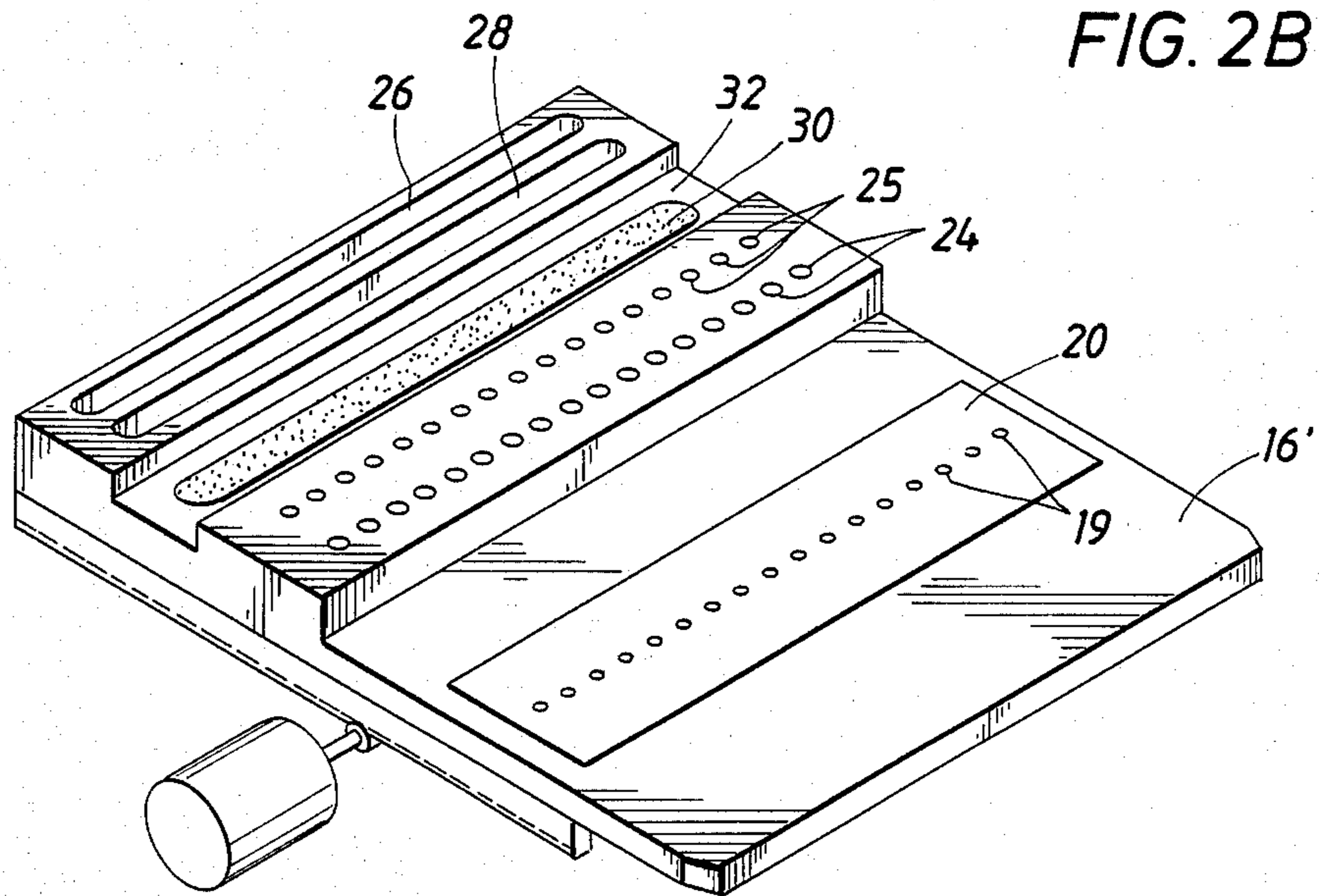
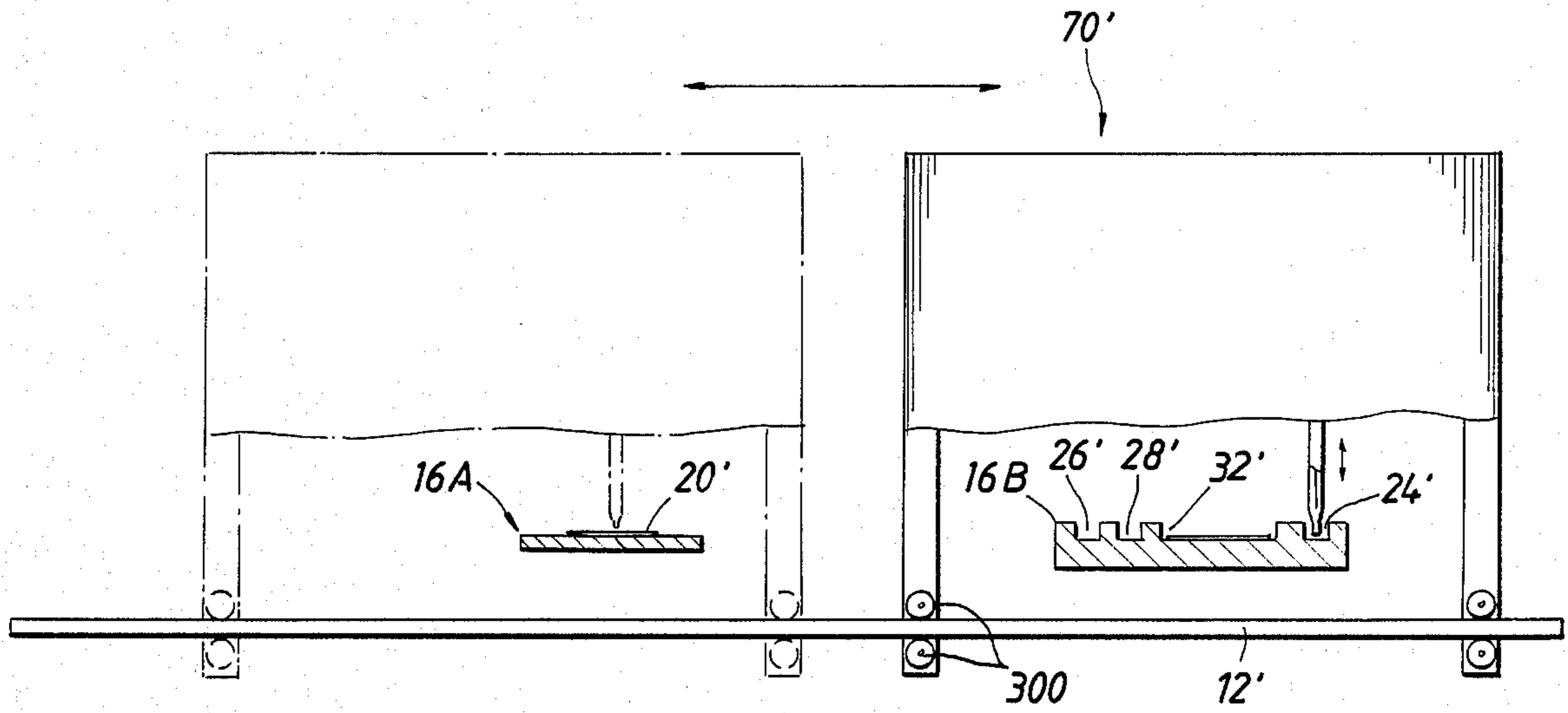


FIG. 2

FIG. 2A



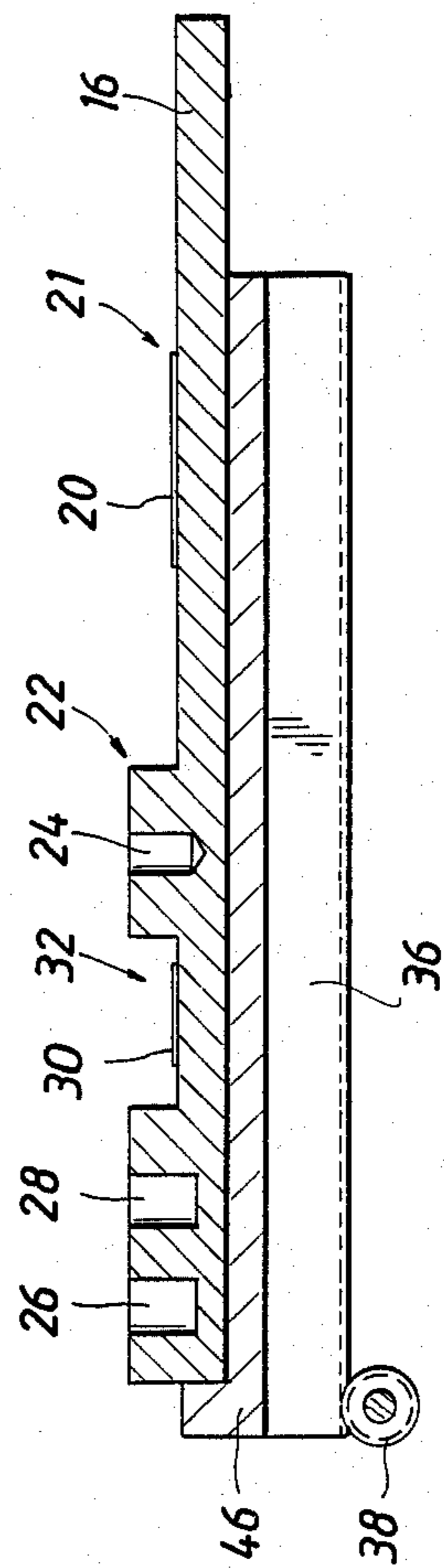
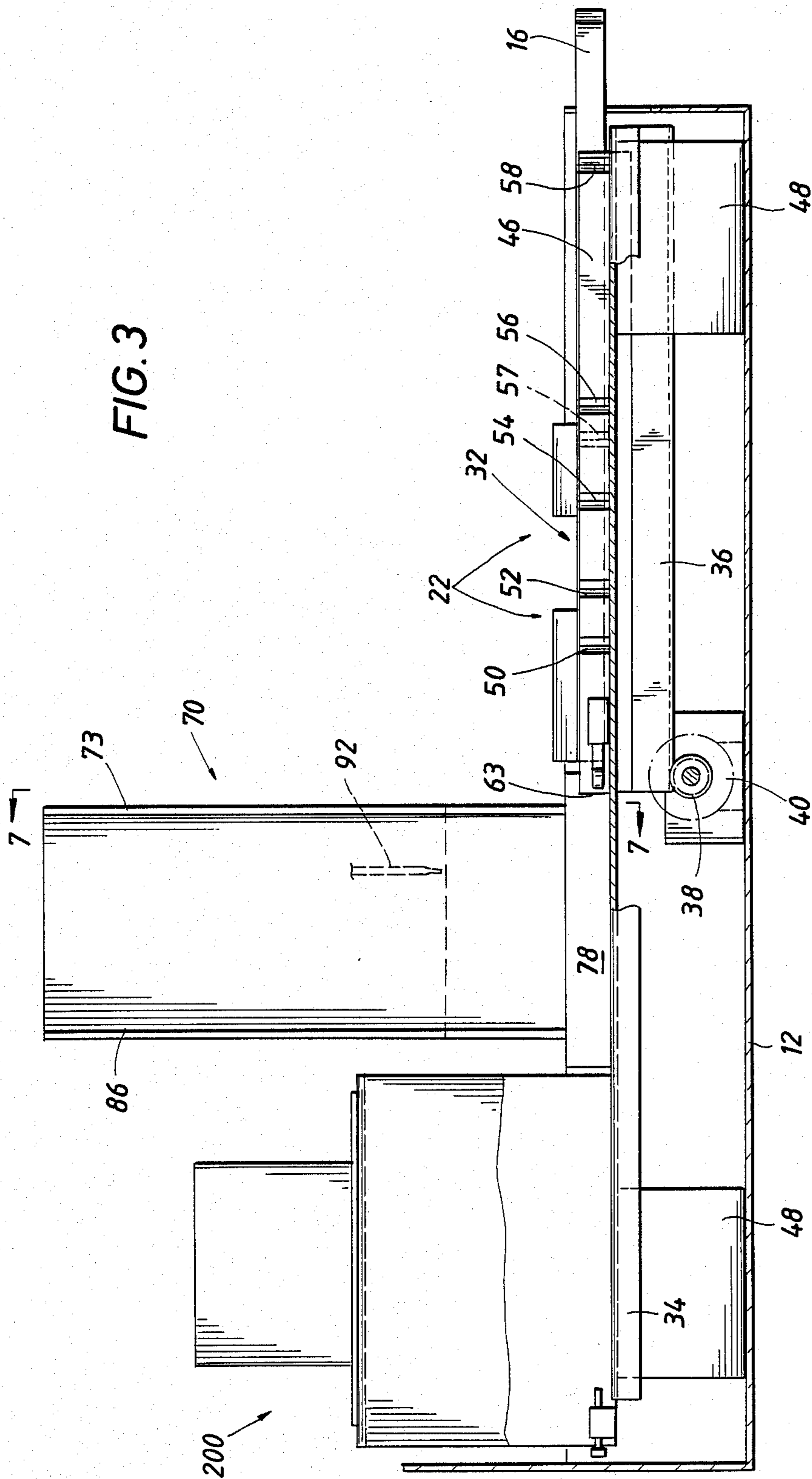


FIG. 5

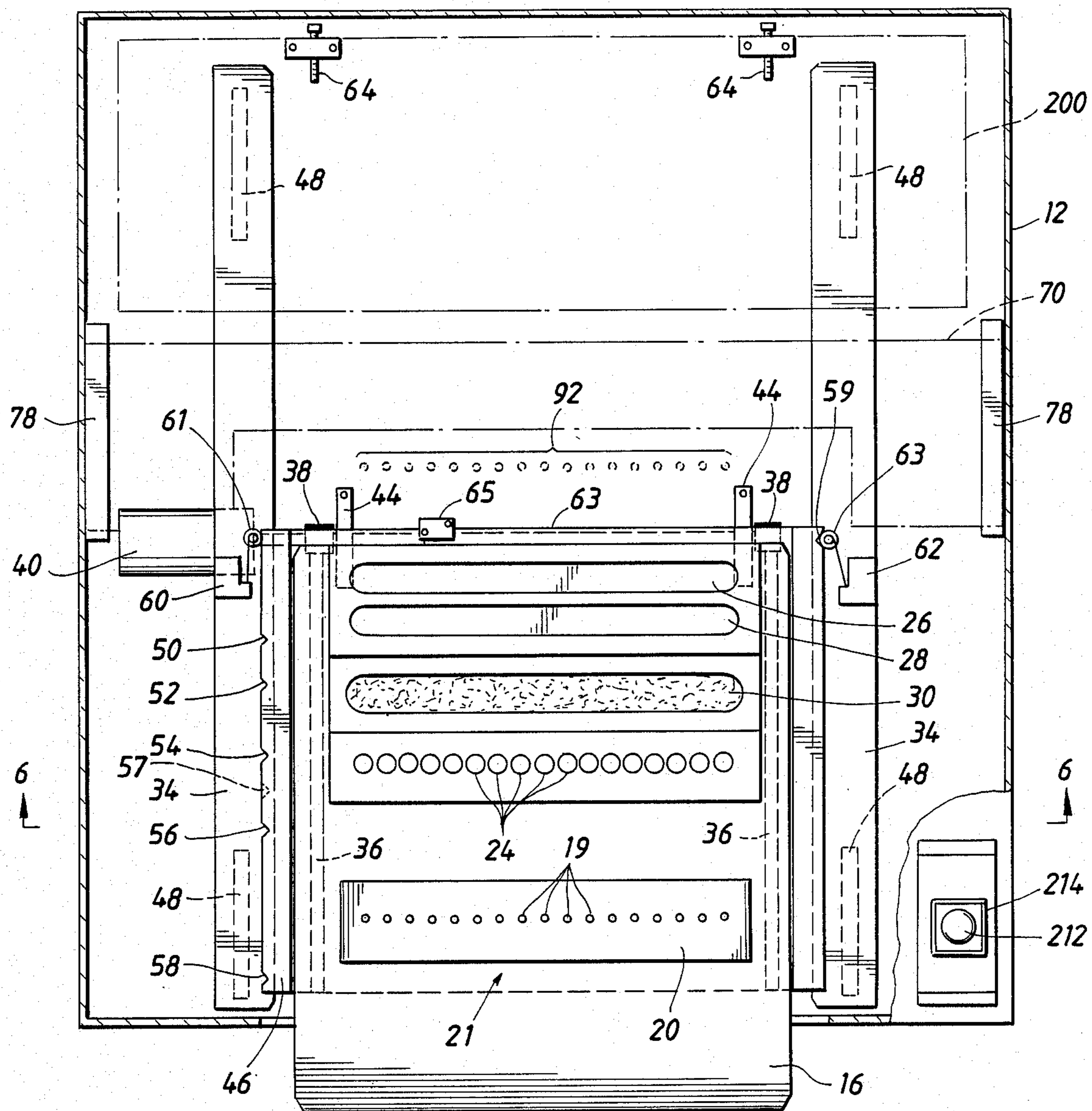


FIG. 6

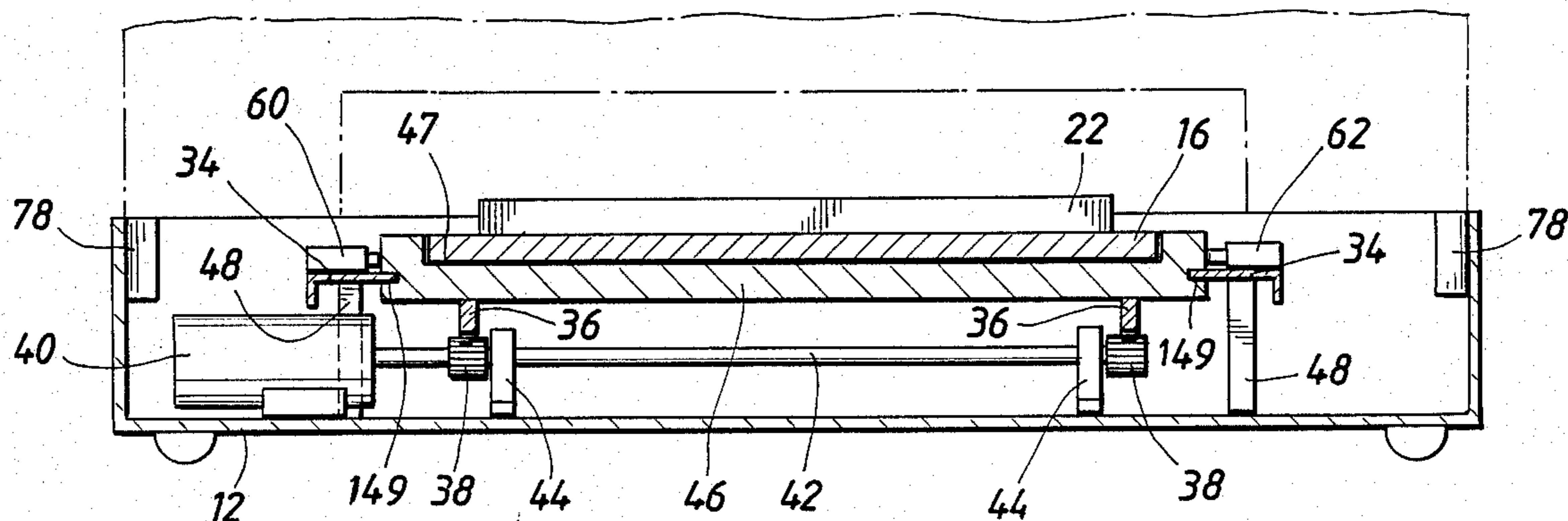


FIG. 8

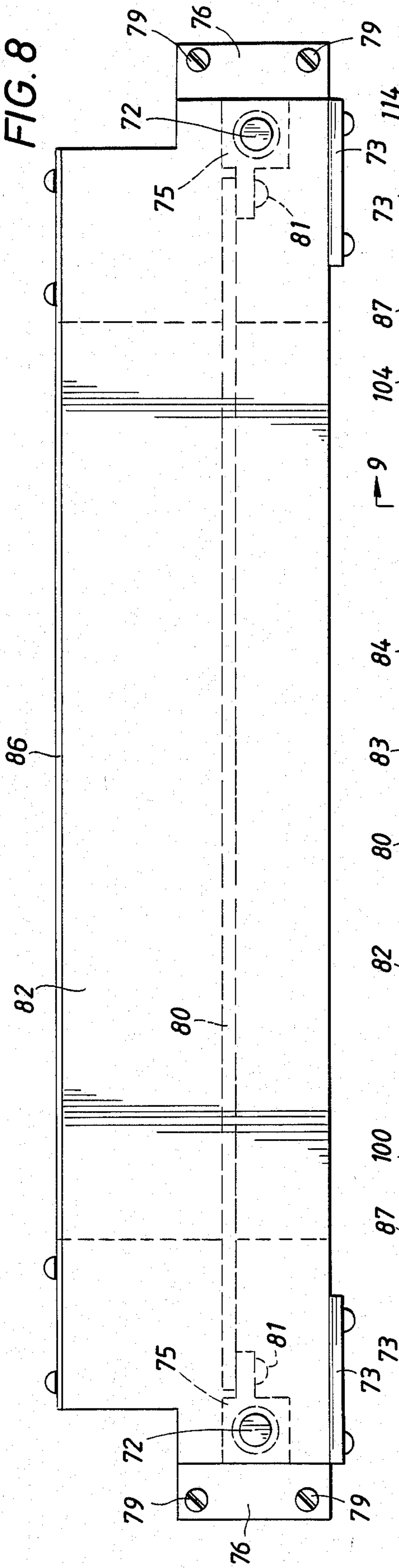
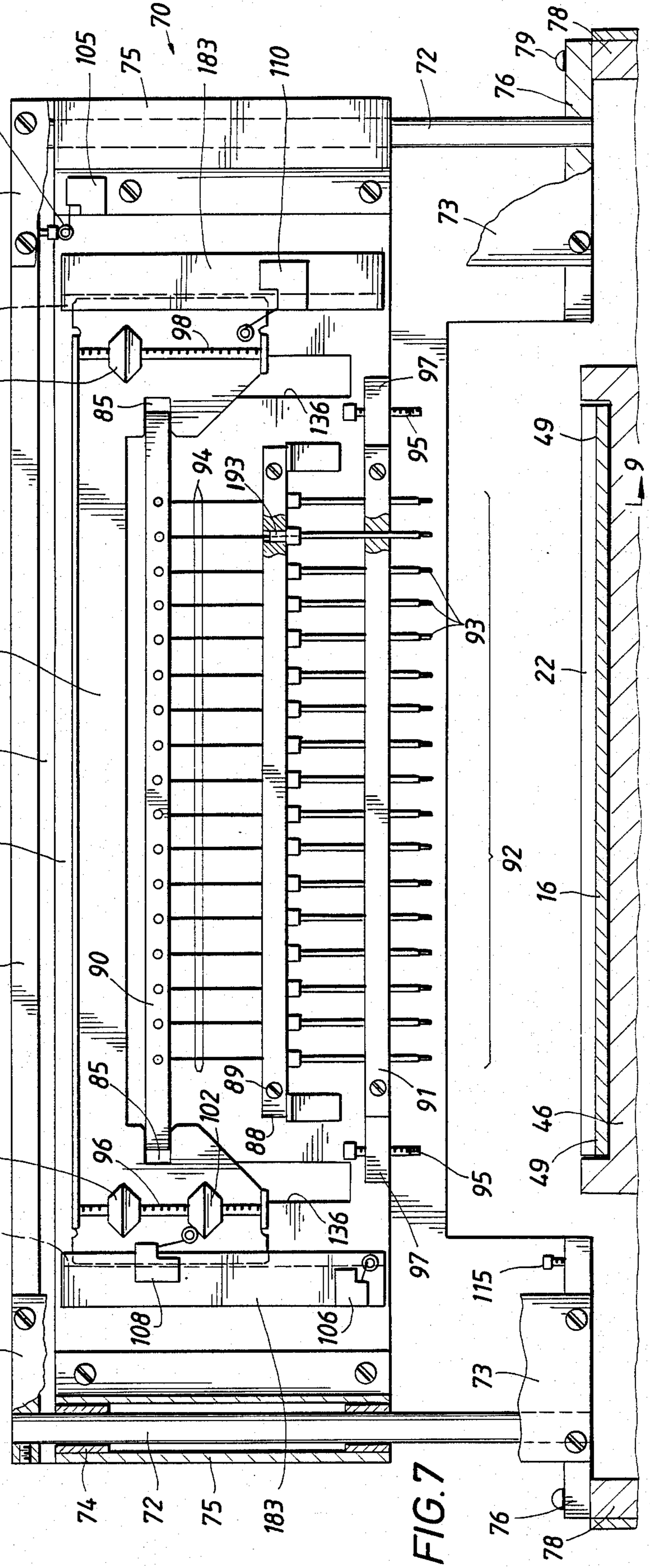


FIG. 7



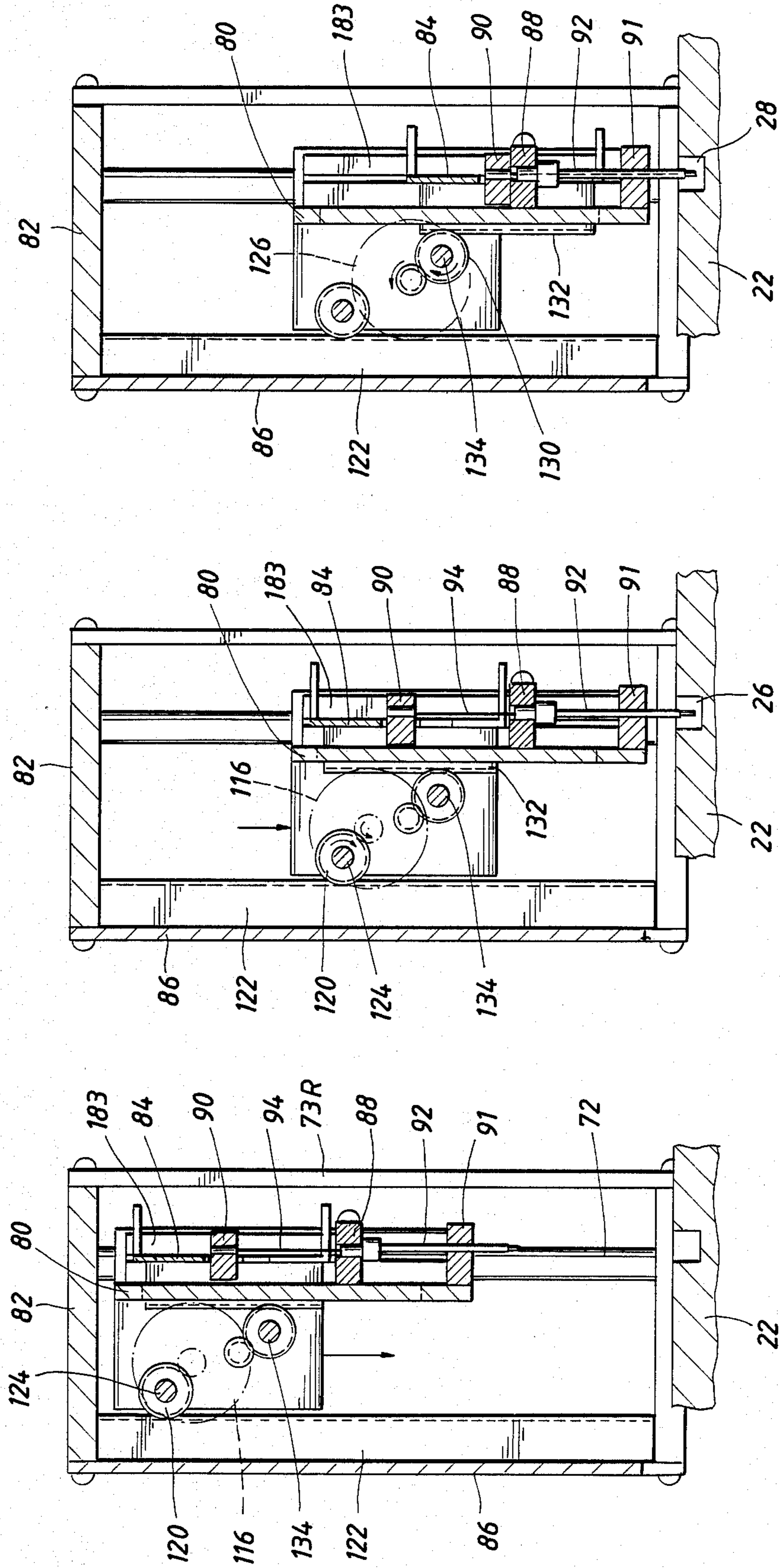


FIG. 9

FIG. 12

FIG. 15





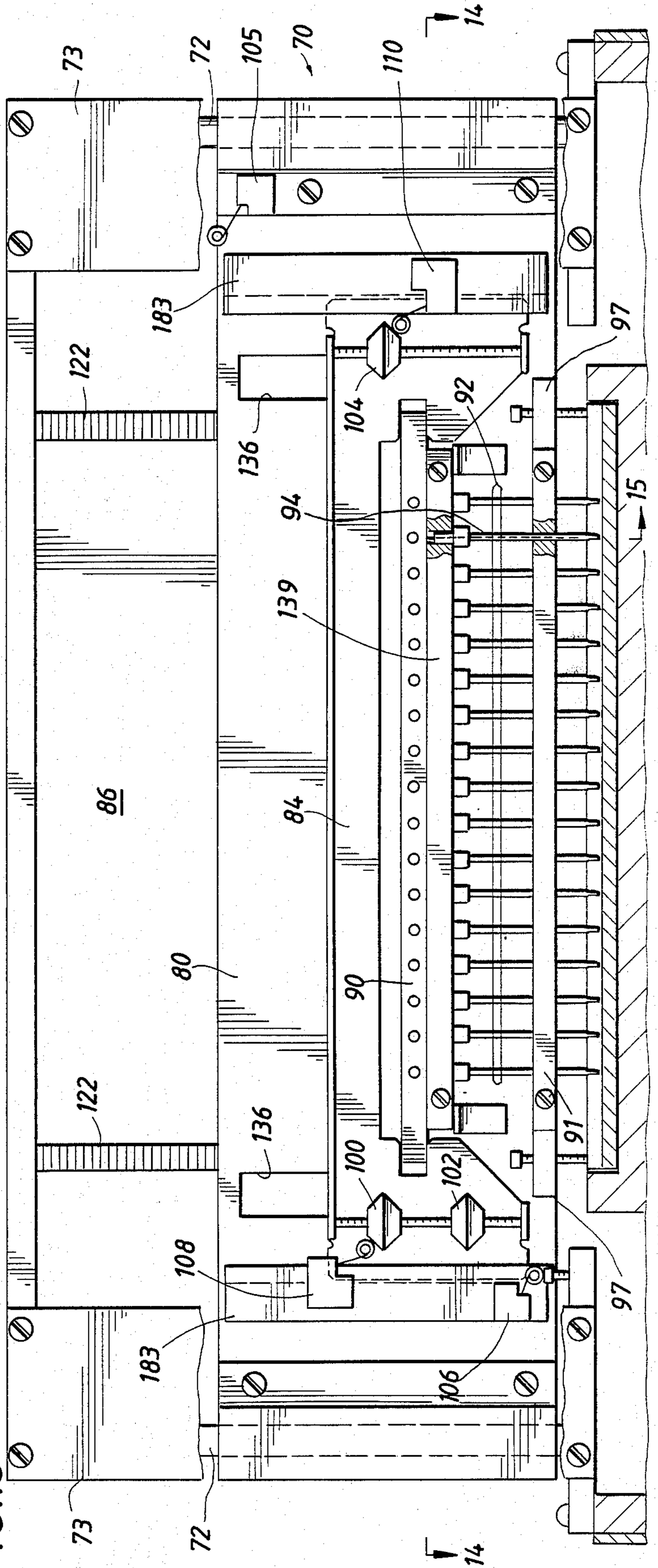
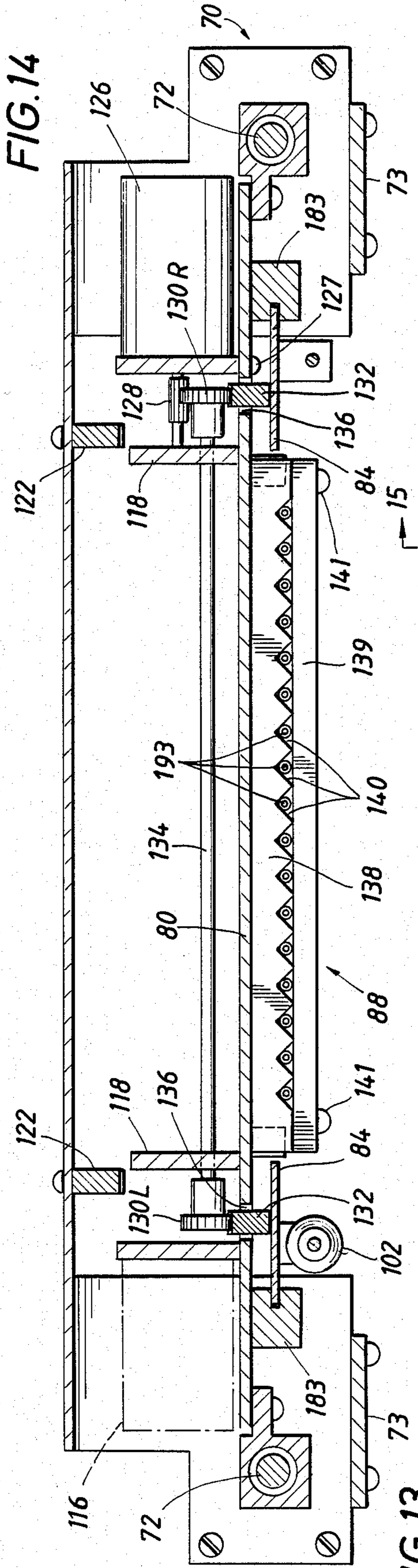


FIG. 16

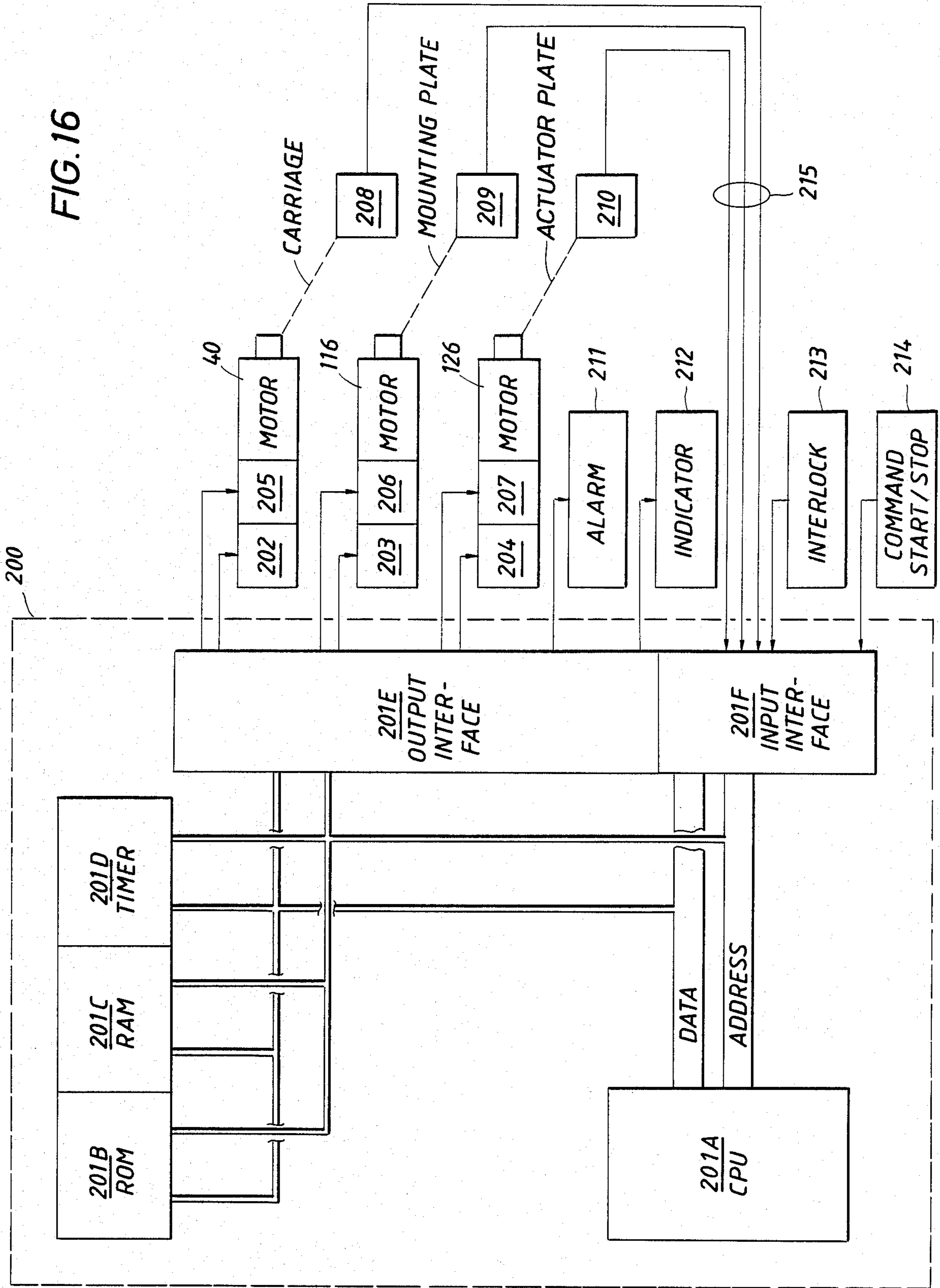
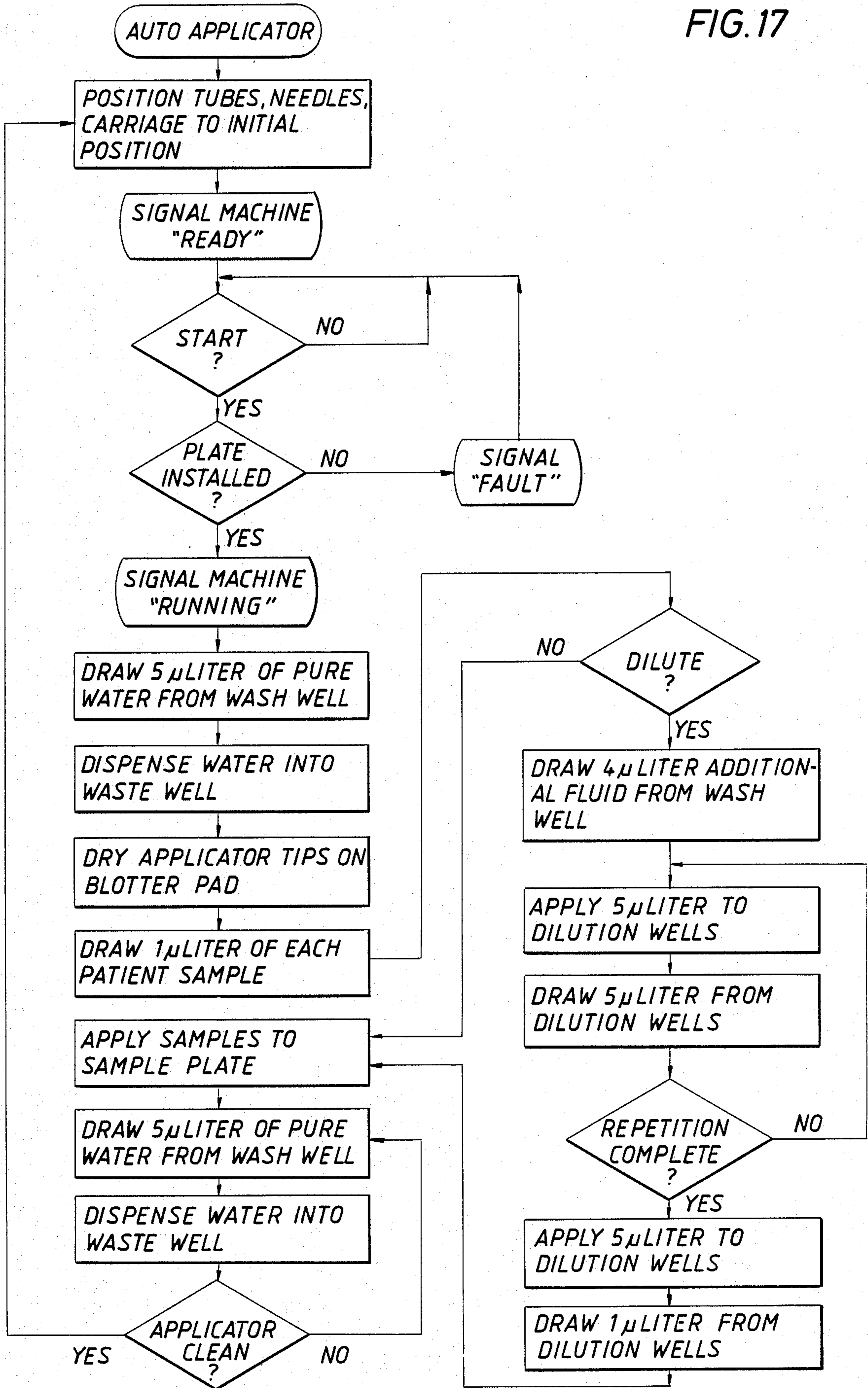


FIG. 17



## AUTOMATIC PIPETTING APPARATUS

This application is a continuation of application Ser. No. 853,201, filed Apr. 17, 1986, now abandoned.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

This invention is related in general to the field of applying fluid samples to analysis strips. In particular, this invention relates to an automatic pipetting apparatus for applying multiple fluid samples to a microporous support medium such as a cellulose acetate or agarose strip which may be used in the field of zone electrophoresis and with other separation techniques including the field of thin layer chromatography. Zone electrophoresis is the science of moving charged particles in an electric field through a solid or semi-solid medium. The technique is most commonly used in medical research and medical laboratories for analyzing various blood proteins.

#### 2. Description of the Prior Art

In the electrophoresis technique, a blood or other fluid sample is applied to a support medium which is then subjected to an electric field so as to separate the components of the sample. The support media used in the electrophoresis process includes cellulose acetate, agar, agarose and acrylamide gels. In laboratory work it is desirable that a plurality of samples be applied to the support medium such that each of the samples may be subjected to the electric field at the same time.

The samples may be applied to the support medium one at a time in serial fashion with a hand pipetter, but the hand pipetter must be rinsed with a cleansing agent and blotted before a new sample is aspirated and then applied to the strip.

Applicators have been designed to apply fluid samples simultaneously or in "parallel" to the strips. Such applicators are described at page 61 of the General Products Catalog for 1984-1985 of Helena Laboratories with offices in Beaumont, Tex. Such applicators may apply eight, twelve or more samples to a microporous support medium and have the advantage of making the electrophoresis technique easier and more reproducible.

The applicators known prior to this invention however have been essentially non-automatic applicators and required cleaning of the applicator tips after each application to the support medium.

Automatic dispensing systems are known in the prior art. For example, a system sold under the trademark "Well Washers" of BioTech Instruments, Inc. of Burlington, Vt. provides an alignment mechanism by which a row of eight or twelve barrels may be positioned above one of a plurality of rows of washing vials or wells. Automation in the system provides selection of dispensing fill volumes, soaking times and number of wash cycles.

None of the prior art however has provided an apparatus for automatically filling a plurality of pipettors from a respective plurality of fluid chambers and then precisely applying such fluid samples from each pipette to a support medium. Another disadvantage of the prior art systems is that there has been no means for automatically washing and cleaning the barrels during each cycle time so as to prevent contamination of each of the barrels during application of a new plurality of fluid samples to a new support medium.

Another disadvantage of the prior art is that there has been no means for precisely automatically applying a very small amount—of the order of one micro liter of sample liquid—to a support medium.

Another disadvantage of the prior art is that there has been no means for precisely automatically diluting a very small amount—of the order of one micro liter—of sample fluid with a diluting liquid, and precisely applying a very small amount of the diluted sample to a support medium.

### IDENTIFICATION OF OBJECTS OF THE INVENTION

It is therefore a primary object of the invention to provide an automatic pipetter apparatus for aspirating from a plurality of sample chamber wells into a corresponding plurality of pipettors and then applying such samples precisely to a microporous support medium to be used in electrophoresis or thin layer chromatography.

It is a further object of the invention to provide an automatic pipetting apparatus which not only aspirates and dispenses sample fluids onto a support medium strip such as cellulose acetate or agarose, but also flushes, cleanses, rinses and blots the tips of the barrels with an appropriate cleaning fluid before and after each application of the sample fluid to the support medium.

It is another object of the invention to provide an automatic pipetting apparatus by which positive displacement pipette barrels and plungers are controlled to precisely apply a very small sample of fluid to a support medium.

It is another object of the invention to provide automatic pipetting apparatus for precisely automatically diluting a very small amount of sample fluid with a diluting liquid and precisely applying a very small amount of the diluted sample to the support medium.

### SUMMARY OF THE INVENTION

The objects identified above as well as other advantages and features of the invention are provided in an automatic pipetting apparatus which generally includes a base and a sample plate disposed on the base and a pipette frame including a vertical support for supporting the frame from the base above the sample plate. The sample plate includes a row of individual liquid sample chambers and a lateral application space longitudinally separated from the liquid chamber row. The lateral application space is adapted to receive a microporous support medium. A mounting plate is carried by the pipette frame.

The apparatus includes translation means for effecting relative longitudinal movement of the pipette frame and sample plate, and vertical translation means for effecting relative vertical movement of the mounting plate and the sample plate.

A plurality of microsyringe barrels are removably secured to the mounting plate. The barrels are spaced corresponding to the spacing of the liquid chambers of the sample plate. A plurality of micro-plungers are provided, one each movably disposed in one of the barrels. A plunger translation means is provided for moving the plunger vertically within the barrels.

Signalling means are provided for generating longitudinal signals representative of the relative longitudinal orientation of the pipette frame with respect to the sample plate, for generating mounting plate signals representative of the vertical orientation of the mounting

plate relative to the sample plate and for generating plunger signals representative of the orientation of the plungers relative to the barrels.

A programmed digital computer is provided responsive to the longitudinal signals, the mounting plate signals and to the plunger signals for generating a sequence of control signals to the longitudinal translation means, to the vertical translation means and to the plunger translation means to aspirate a predetermined amount of liquid from the sample chambers into the respective pipette barrels, and to apply the liquid samples in the barrels onto corresponding spaces or "spots" on the microporous support medium when placed on the lateral application space of the sample plate.

One embodiment of the invention includes a base having a track disposed longitudinally on it. A carriage is longitudinally movably disposed on the track [means] and carries a sample plate which is removably disposed on the carriage. The carriage plate includes a lateral row of individual liquid sample chambers and a lateral application space which is longitudinally separated from the liquid chamber row. The lateral application space is adapted to receive a microporous support medium such as a cellulose acetate or agarose strip used in electrophoresis or thin layer chromatography.

A pipette assembly is mounted vertically on the base above the carriage and the sample plate. The pipette assembly includes vertical mounting posts separated laterally from each other and secured to the base. A mounting plate assembly is slidably guided by the posts and is disposed laterally with respect to the sample plate.

The mounting plate assembly includes a mounting plate having slidable guides disposed about the posts. A pipette bar is fixed to the mounting plate. A plurality of microsyringe barrels are provided in a row on the pipette bar with their heads secured thereto. The microsyringe barrels are spaced corresponding to the spacing of the liquid chambers on the plate. The barrels are hollow, each barrel having a lower tip.

A plunger bar is vertically movably disposed above the tip bar and has a plurality of micro-plungers secured thereto. Each of the micro-plungers are movably disposed within a corresponding barrel of the microsyringes. A plunger actuator plate carried by the mounting plate is vertically movable with respect to the mounting plate. The actuator plate is removably secured to the plunger bar.

Translation and signalling means are provided for moving the carriage longitudinally forward and backward beneath the mounting plate assembly and generating carriage position signals indicative of the carriage position. A translation and signalling means is provided for moving the mounting plate assembly up and down with respect to the base and generating mounting plate position signals indicative of the mounting plate position. A translation and signalling means for moving the plunger bar up and down with respect to the mounting plate and generating plunger bar position signals indicative of the plunger bar position is provided.

A programmed microcomputer is provided responsive to the carriage position signals, to the mounting plate position signals, and to the plunger bar position signals for generating a sequence of control signals to the translation means for moving the carriage, the translation means for moving the mounting plate, and the translation means for moving the plunger bar so as to aspirate a first predetermined amount of liquid from the

sample chamber into the respective pipette barrels and then to apply the liquid in each of the pipette barrels onto corresponding spaces of the support medium when placed on the lateral application space of the sample plate.

The sample plate includes a wash well and waste well longitudinally spaced from each other and from the sample chamber. The programmed computer generates a further sequence of control signals to the translation means before aspirating liquid from the sample chambers to draw a second predetermined amount of rinse liquid from the wash well into the respective pipette barrels and then to discharge that rinse liquid into the waste well.

The apparatus further provides the sample plate with a longitudinal blotting space for applying a lateral blotting paper strip where the blotting space is longitudinally separated from the sample chamber row, the wash well, the waste well and the lateral application space. The programmed computer generates a further sequence of control signals to the translation means after discharging the wash liquid into the waste well so as to blot the lower tips of the barrel on the blotting paper strip.

Preferably, the sample plate includes a raised portion and a lower portion where the row of individual liquid sample chambers and the wash well and the waste well are disposed on the raised portion and the lateral application space and the blotting space are disposed on the lower portion.

The sample plate may include a row of liquid dilution wells longitudinally spaced from the sample chambers. The programmed computer includes a program, actuated by a dilution signal, for automatically controlling the apparatus for diluting the samples aspirated to the microsyringe barrels with dilution fluid and mixing the sample and dilution fluid in each of the dilution wells before mixed diluted sample fluid is applied to the spots of the support medium.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The objects, advantages and features of the invention will become more apparent by reference to the drawings which are appended hereto and wherein like numerals indicate like parts and wherein an illustrative embodiment of the invention is shown, of which:

FIG. 1 shows a perspective view of one embodiment of the automatic pipetting apparatus of the invention with a sample plate secured thereto and its cover attached;

FIG. 2 is a schematic illustration of the invention showing the functional relationship between the sample plate with its sample chambers, wash well, waste well and a longitudinal application space with a microporous support medium secured thereto beneath a pipette assembly in which individual pipette barrels are moved as a unit up and down and a plunger bar secured to plungers which are moved up and down with respect to the barrels;

FIG. 2A schematically shows another embodiment of the invention where the mounting plate includes two stationary units and the pipette frame is longitudinally movable with respect to the plate;

FIG. 2B is a perspective view of another embodiment of the sample plate further including a row of dilution wells;

FIG. 3 is a side view partially cut away and in section with the cover removed and taken from the view along lines 3—3 of FIG. 1;

FIG. 4 is a cross-section of the carriage and the sample plate;

FIG. 5 is a downward looking view along lines 5—5 of FIG. 1 and shows the cross-section of the base at level 5—5 and the track, carriage and sample plates beneath the pipetting assembly;

FIG. 6 is a cross-sectional view taken along lines 6—6 of FIG. 5 and shows the base, the carriage and sample plate according to the invention and further shows the translation and guiding means by which the track is moved forward and backward with respect to the pipetting assembly;

FIG. 7 is a forward looking view taken along lines 7—7 of FIG. 3 and shows partially broken away, partially cross-sectional parts of the pipette assembly slidably mounted on posts secured to the base and including a mounting plate which moves up and down with respect to the base and carrying a row of barrels of individual pipettes and an actuator plate movable vertically with respect to the mounting plate for moving a plunger bar vertically for moving individual plungers within the barrels of each of the pipettes;

FIG. 8 shows a top view of the pipette assembly showing in dashed lines the mounting plate of the pipette assembly;

FIG. 9 shows a cross-sectional view taken along lines 9—9 of FIG. 7 and illustrates the relationship between the mounting plate, the tip bar and the plunger bar and the means by which the mounting plate is moved up and down with respect to the base;

FIG. 10 is a similar view to that of FIG. 7 but shows the mounting plate having been translated to a lower position but with the plunger bar remaining in an upward position whereby the tips of the pipetters are in a downward position, but the plungers are extended upwardly from each of the barrels of the pipettes;

FIG. 11 is a top cross-sectional view taken along lines 11—11 of FIG. 10 and illustrates the motor and rack and pinion system by which the mounting plate is moved up and down with respect to the base;

FIG. 12 is a cross-sectional view taken along lines 12—12 of FIG. 10 and illustrates the relationship of the mounting bar after it has been moved downwardly by the rack and pinion system by operation of the motor turning with respect to the frame mounted rack;

FIG. 13 is a view similar to that of FIGS. 7 and 10 but illustrates the plunger actuator plate and plunger bar moved downwardly with respect to the mounting plate thereby forcing the plungers associated with each of the pipetters into their barrels and forcing any fluid previously aspirated into the barrels out the tips of the barrels;

FIG. 14 shows a cross-sectional view taken along lines 14—14 of FIG. 13 and illustrates the rack and pinion system by which the actuator plate and the plunger bar secured thereto is moved up and down with respect to the mounting plate;

FIG. 15 is a cross-sectional view taken along lines 15—15 of FIG. 13 and illustrates the movement of the actuator plate downwardly with respect to the mounting plate by operation of the rack and pinion system controlling relative movement between the actuator plate and the mounting plate;

FIG. 16 is a schematic illustration of the microcomputer integrated circuit device receiving signals from

position detector circuits associated with the carriage, the mounting plate and actuator plate and applying translation signals to motors for positioning the carriage, the mounting plate and the plunger actuator plate; and

FIG. 17 is a functional flow chart illustrating the stored program in the microcomputer device for automatically washing, blotting, sampling and applying samples to the support medium strip.

## DESCRIPTION OF THE INVENTION

FIG. 1 illustrates in a perspective view the automatic pipetting apparatus 10 according to the invention. The apparatus includes a base 12 on which a sample plate 16 is movably supported. The sample plate includes a space 21 for securing a microporous support medium 20 such as a cellulose acetate or agarose strip used in the field of zone electrophoresis or other separation techniques including the field of thin layer chromatography. A cover 14 is provided behind which a pipette head 18 is shown.

FIG. 2 is a schematic illustration of the essential mechanical elements of one embodiment of the invention with the base and the cover removed. None of the mounting apparatus is shown in FIG. 2 so as to simplify the explanation of the relationship of the sample plate 16 to the pipette assembly 70. The translational means are shown in a functional way rather than in actual mechanical detail which will be shown in detail in the figures and discussion below.

The sample plate 16 as shown includes a row of sample chambers 24 as well as a wash well 26, rinse or "waste" well 28 and a longitudinal space 21 on which a microporous support medium 20 is removably secured. The sample chambers 24, the rinse well 28 and the wash well 26 are provided on raised portions 22 of the sample plate. If desired, a plastic cup may be provided in each of sample chambers 24. A blotter space 32 between the rinse well 28 and the sample chambers 24 is provided at substantially the same vertical level 49 as the sample application space 21 on which the support medium 20 is secured.

As illustrated in FIG. 2, the various regions of the sample plate are longitudinally distinct, yet the lateral spacings between the sample chambers 24 corresponds to the application spots 19 on the support medium 20 which is indicative of the fact that the barrels 92 of the pipette assembly 70 are arranged in a row corresponding to the sample chambers 24. Liquid from those chambers is aspirated by the automatic pipetting apparatus and is applied in a similar row on the spots 19 of the microporous support medium 20.

It is advantageous to provide the sample chambers 24, waste well 28 and wash well 26 in raised portions 22 of the sample plate 16 so that the mounting plate 80 of the pipette assembly 70 need only go down to a common downward position during all wash, waste, blot, sampling and application operations. However, it would be obvious to one of ordinary skill in the art that other arrangements could be provided especially where different levels of the mounting plate could be provided in the translation and signalling apparatus for controlling the mounting plate 80. A detailed discussion of such translation and signalling apparatus for controlling the mounting plate 80 is discussed below.

The schematic illustration of FIG. 2 shows that the sample plate 16 is translated in forward and rearward directions beneath the pipette assembly 70 by virtue of

the motor 40 turning a pinion 38 having its gears in engagement with those of rack 36. As the shaft of the motor 40 turns, the sample plate 16 carried by the rack 36 moves back and forth beneath the pipette assembly 70.

Turning now to the pipette assembly 70 shown in FIG. 2, a mounting plate 80 is translated upwardly and downwardly by means of mounting plate motor 116 having its pinion 120 engaging a rack 122. Thus, the entire mounting plate 80, and the microsyringe barrels 92 attached to the barrel bar 88 which is secured to the mounting plate 80, moves up and down in accordance with the turning of the mounting plate motor 116. Similarly, the plungers 94 which are attached to plunger bar 90 and actuator plate 84 are moved up and down with respect to mounting plate 80 by operation of the turning of actuating plate motor 126 and its pinion 130 engaging actuator rack 132. For purposes of illustration, the actuator plate motor 126, its pinion 130 and the actuator plate rack 132 are shown on the forward side of mounting plate 80, but the actual apparatus illustrated in the subsequent figures is to the rearward side of the mounting plate 80 through slots in it.

FIG. 2 therefore shows all of the essential elements as far as the translation of the sample plate 16 backward and forward beneath the microsyringe barrels 92 and illustrates the upward and downward translation means of the mounting plate 80 and the microsyringe barrels 92, and the upward and downward motion of the plungers 94 and the plunger bar 90 and actuator plate 84 with respect to the mounting plate 80.

FIG. 2A schematically illustrates an alternative embodiment of the invention where the sample plate remains immovable with respect to the base 12' with the pipette assembly 70' being mounted on rollers 300 for longitudinal translation. FIG. 2A illustrates that the sample plate may include two units, an application plate unit 16A and a fluid plate unit 16B. The sample plate unit 16A is adapted to removably secure a support medium 20', while the fluid plate unit 16B includes a row of sample chambers 24', a waste well 28', a wash well 26' and a blotting space 32'. The operation of the alternative embodiment is similar to that of the embodiment of FIG. 2 except that translation and signalling means are provided for longitudinally translating pipette assembly 70' with respect to the sample plate(s) 16A, 16B. Details of such translation and signalling means will be apparent to one of ordinary skill in this art by virtue of the detailed description of analogous translation and signalling means described below.

FIG. 2B illustrates an alternative sample plate 16' which may include an additional row of dilution wells 25 in addition to the row of sample chambers 24, waste well 28, wash well 26 and blotting space 32. Explanation of the automatic diluting of sample fluid will be described below with reference to FIG. 2B.

FIG. 3 is a side view taken along lines 3—3 of FIG. 1 with a portion of track 34 cut away to show its construction. The tracks 34 are supported by track supports 48 which may also be seen in FIG. 5. The pipette assembly 70 is vertically supported from base mounting block 78 which is secured to the sides of the base 12 and is also further illustrated in FIG. 5. The pipette assembly 70 includes a back plate 86 and a front plate 73. One of the plurality of barrels 92 of the pipette assembly is shown in an upward position.

A carriage 46 is slidably movably disposed on track 34 as more clearly seen in FIG. 6. Racks 36 are secured

to carriage 46 and are movable with respect to the base 12 by means of the carriage motor 40 having its pinion 38 in engagement with rack gear 36.

Notches are provided along the left edge of the carriage 46. These notches cooperate with a trip switch to provide signals indicative of the longitudinal position of the carriage. The wash notch 50, rinse notch 52, blot notch 54, sample chamber notch 56, dilution chamber notch 57 (where the alternative sample plate 16' of FIG. 2B is used) and application notch 58 are illustrated in FIG. 3.

FIG. 4 illustrates a vertical cross-section through the carriage 46 and the plate 16 and shows the actual wash well 26, rinse well 28 and one of the sample chambers 24 on raised portion 22 of the plate 16. A blotter space 32 and a lateral application space 21 are illustrated on plate 16. Blotter paper 30 is shown in blotter space 32 while a microporous support medium 20 such as cellulose acetate or agarose is secured in lateral application space 21.

FIG. 5 is a downward view taken along lines 5—5 of FIG. 1. Carriage 46 is shown supported by tracks 34 and movable in the rearward and forward directions by means of motor 40, pinion 38 and rack 36 as also illustrated in FIG. 6. The sample plate 16 is disposed in a valley or U-shaped cross-sectional structure 47 of carriage 46.

Position signalling notches on the sides of the carriage 46 cooperate with trip switch 60 and trip switch 62 fixed to tracks 34. Spring loaded rollers 61 and 63, respectively are forced against the longitudinal edges of carriage 46 and into the notches as the carriage 46 moves past them. For example, the notches on the left hand side 46 include the wash notch 50, the waste notch 52, the blot notch 54, the sample chamber notch 56 and an application notch 58. The notches correspond to the longitudinal position of the wash well 26, waste well 28, blotter paper 30, sample chambers 24 and application spots 19 when those wells, chambers and blotting and application spots are directly beneath the pipette barrels 92.

When the carriage 46 moves rearwardly where the wash well 26 is directly beneath the barrels 92, the roller 61 moves into the wash notch 50 thereby tripping the trip switch 60 for signalling the microprocessor associated with electronic module 200 (FIGS. 3 and 16) that the wash well is beneath the barrels 92. The trip switch 60 is likewise tripped when the roller 61 enters notches 52, 54, 56 and 58 to signal the position of the respective other wells, chambers and spots beneath the barrels 92.

On the right hand side of the carriage 46 is notch 59 in which the roller 63 is shown. A sample plate trip switch 62 is thereby tripped to indicate that the carriage is at its maximum forward position. Trip switch 65 is mounted on the rear edge of carriage 46. Switch 65 closes when the rear edge of the plate 16 is in position and engages it thereby generating a signal that the plate 16 is properly in position on carriage 46. The stops 64 provide means for accurately longitudinally positioning application spots 19 beneath barrels 92 when carriage 46 is in the maximum rearward position.

Also shown in FIG. 5 is a start button 214 by which the programmed microprocessor is signalled to start the automatic sequence of events for the automatic pipetting apparatus which will be explained in detail below. Lamp 212 provides a visual indication to the user of the

automatic pipetting apparatus 10 that the power is turned on.

FIG. 6 illustrates in a cross-sectional view taken along lines 6—6 of FIG. 5 the means by which the carriage is translated with respect to tracks 34. The tracks 34 are supported upon base 12 by means of supports 48. The carriage 46 includes slots 149 in its sides on which it slides on tracks 34.

Plate 16 as indicated above is disposed within a notch or valley 47 of the carriage 46. The carriage translation motor 40 is fixed to the base 12 and includes a shaft 42 which is supported by means of shaft supports 44. Pinions 38 secured to shaft 42 have their gears in engagement with racks 36 which are attached to the carriage 46. As the motor 40 is turned in one direction or the other under control of the microprocessor in the electronic module 200 (FIG. 16), the carriage 46 moves in the forward or rearward directions.

FIG. 7 illustrates the pipette assembly 70 looking rearwardly along lines 7—7 of FIG. 3. The mounting blocks 76 are shown secured to the base mounting blocks 78 by means of screws 79. The mounting blocks 76 carry vertical mounting posts 72 as illustrated in FIGS. 7, 10 and 13 and in the top views of FIGS. 8, 11 and 14. The front plates 73 and back plate 86 are secured by means of screws to mounting blocks 76.

A mounting plate 80 is vertically slidably supported about the vertical mounting posts 72. Retainer bearings 74 provide sliding engagement between the posts 72 and vertical bearing blocks 75. The mounting plate 80 is fastened to extensions of bearing blocks 75 by means of screws 81. By reference to FIGS. 7 and 13, it is seen that mounting plate 80 may be moved from its upward position as shown in FIG. 7 to its lower position as shown in FIG. 13 by its attachment to bearing blocks 75 and their sliding engagement on posts 72.

A barrel bar 88 is secured to mounting plate 80 by means of screws 89. Mounted on barrel bar 88 are a plurality of pipette barrels 92 having their heads 193 secured within the barrel bar 88 in a manner to be described below. As illustrated in the partial cut away of barrel bar 88, the barrel lock bar 91 secures the lower portions of the barrels 92 to provide stability to the barrels. Guide tips 97 include adjustable screws 95 extending below the bottom edge of the mounting plate 80 which cooperate with the lower surfaces 49 of plate 16 to accurately vertically position the lower tips 93 of barrels 92 with respect to the support medium 20 and blotting paper 30 disposed on lower surface 49 of plate 16. Such adjustment allows the droplets which form on the ends of the tips 93, when plungers 94 are driven downwardly within barrels 92, to "kiss" or be slightly applied either to the support medium or the blotting paper. The droplets on the lower tips 93 of the barrels 92 are held because of their small size (as small as one micro liter) and surface tension forces of the barrel tips. When the tips are brought to a small distance within the upper surface of the support medium 20 or blotting paper 30, the droplets are relieved of the surface tension holding them to their barrels and are precisely applied to the blotting paper or to the support medium.

Actuator guides 183 are secured to the mounting plate 80 and include grooves in which an actuator plate 84 is inserted for sliding movement upwardly and downwardly with respect to the mounting plate 80. The actuator plate 84 has grooves in which a plunger bar 90 is inserted. The plungers 94 of the microsyringe barrels 92 are secured to the plunger bar 90 and extend within

the barrels 92. As illustrated in FIG. 7, the plungers 94 are at their uppermost extent with respect to the barrels 92. The actuator plate 84 is adapted to move downwardly with respect to the mounting plate 80, and through such action, the plunger bar 90 moves downwardly with respect to the barrel bar 88 causing plungers 94 to move downwardly within the barrels 92 thereby forcing any fluid within such barrels outwardly through the tips 93 of the barrels and forming a droplet at the tips of the barrels.

Position signals are generated indicative of the position of the mounting plate 80 with respect to the base 12 and the position of the actuator plate 84 and its plungers 94 with respect to the mounting plate 80. The trip switch 106 mounted on the mounting plate 80 cooperates with the lower stop 115 mounted on the mounting block 76 to provide a lower mounting plate position signal when the mounting plate 80 reaches its lower extent. In a similar way as shown on the right hand side of the mounting plate 80, the upper trip switch 105 is mounted on the mounting plate 80 and is shown tripped by contact with the upper stop 114. The upper trip switch 105 when tripped provides a signal to the microprocessor of electronics module 200 (FIG. 3) indicative that the mounting plate 80 is in its upper position.

The trip switch 108 mounted on left hand side actuator 183 cooperates with application position cam 100 and wash cam 102. The trip switch 108 is tripped by the application cam 100 when the actuator plate 84 moves upwardly with respect to the mounting plate 80 and the trip switch 108 is tripped by wash cam 102 as the actuator plate 84 moves further upwardly. The down cam 104 trips trip switch 110 mounted on the right hand side actuator guide 183 when the actuator plate 84 reaches its maximum downward travel where the plungers 94 are within the barrels 92.

FIG. 9 is a cross-sectional view taken along lines 9—9 of FIG. 7 and illustrates the mounting plate 80 and the actuator plate 84 both in their upward positions. Mounting plate motor 116 has driven the mounting plate 80 to the upward position by operation of pinion 120 on rack 122 which is secured to the back plate 86 and to the base of the apparatus.

Turning now to FIG. 10, the pipette assembly 70 is shown with the mounting plate 80 in the downward position but the plunger bar 90 and the plungers 94 are in their upward position with respect to the barrel bar 88. The barrels 92 are in a downward position in the wash well for aspirating 5  $\mu$ l fluid, for example, from the wash well 26.

FIG. 11, a view of the pipette assembly looking downwardly along lines 11—11 from FIG. 10, illustrates the drive mechanism by which the mounting plate 80 is moved up and down with respect to the base. A mounting plate actuator motor 116 is fixed to the mounting plate 80 by means of a mounting screw 117. The output shaft of the motor 116 has a gear 119 fixed to it. Gear 119 is engaged with a left pinion gear 120L which is mechanically coupled to a right pinion gear 120R by means of shaft 124. The shaft is mounted to the mounting plate 80 by shaft mountings 118. Racks 122, fixed to the back plate 86, have their gears in engagement with pinion gears 120L and 120R. As the motor 116 turns in either direction under microprocessor control, the mounting plate 80 is moved upwardly or downwardly with respect to the base and the back plate 86 by the rack and pinion mechanism. The front view (FIG. 10) of the pipette assembly 70 with the mounting plate



80 in a downward position shows the racks 122 visible. The front view also illustrates, with the mounting plate 80 in its maximum downward position, that stop screws 95 of guide tips 97 are slightly above surfaces 49 of the plate 16 indicative that tips 93 are slightly above the top edge 49 of the plate so that droplets which form on the tips may "kiss" the surface 49 and apply sample fluid to the support medium or blotting paper.

FIG. 12 is a cross-sectional view of the pipette apparatus taken along lines 12—12 of FIG. 10 and shows that the mounting plate actuator motor 116 has turned its pinion gear 120 so that the mounting plate 80 has been moved downwardly with respect to the base and the raised portion 22 of the plate 16. Thus, the barrel 92 has been lowered to be within a well of the raised portion 22 of the sample plate. A wash well 26 is illustrated as an example where the barrels 92 of the pipettes have been lowered by the mounting plate 80 and where the fluid from the wash wells have been aspirated into barrels 92 by virtue of the plungers 94 being pulled upwardly by means of the actuator plate 84. It is apparent from FIGS. 11 and 12 that the mounting plate 80 is translated upwardly and downwardly with respect to the raised portion 22 by means of the motor 116 turning and causing the pinion 120 to translate upwardly and downwardly on fixed rack 122.

Turning now to FIG. 13, the state of the pipette apparatus 70 is such that the actuator plate 84 has moved downwardly causing the plungers 94 to be inserted back into the barrels 92 thereby positively displacing any fluid which has been aspirated within the barrels either to an application space, a blotter, or to a waste well. It is seen that the trip switch 108 has been returned to a condition such that any upward movement of the actuator plate 84 will be tripped first by the application cam 100 and then the wash cam 102 providing a means for signalling the position of the actuator plate 84 with respect to the mounting plate 80.

FIG. 14, is a downward looking view along lines 14—14 of FIG. 13 and illustrates the drive mechanism by which the actuator plate 84 is translated upwardly and downwardly with respect to the mounting plate 80. A plunger bar actuator plate motor 126 is fixed to the mounting plate 80 by means of a mounting screw 127. The motor 126 includes a gear 128 on its output shaft which is in engagement with pinion gear 130R. Pinion gear 130R is coupled to a pinion gear 130L by means of a shaft 134 which is supported by means of shaft mountings 118 which also supports shaft 124 (see FIG. 11). The actuator plate 84 has actuator plate racks 132 fixed to the rear side thereof which extend through slots 136 in the mounting plate so as to engage the pinions 130L and 130R. As the plunger bar actuator plate motor 126 is caused to turn in either the clockwise or the counter-clockwise direction, the actuator plate 84 is caused to move upwardly or downwardly with respect to the mounting plate 80. FIG. 13 shows the slots 136 in the mounting plate 80 through which the actuator plate racks 132 extend.

FIG. 14 also shows the means by which the barrel heads 193 of the barrels 92 are removably fixed to the barrel bar 88. The barrel bar 88 comprises a receiving bar 138 having slots 140 provided along its front face. The barrel heads 193 are inserted therein and secured by means of a securing bar 139 which holds the barrels vertically in place. The securing bar 139 is secured to the receiving bar 138 by means of screws 141. The barrel lock bar 91 similarly constructed as the barrel bar

88. The barrel bar 88 provide a removably securing means by which the barrels 92 may be easily replaced due to wear or breakage.

FIG. 15 is a cross-sectional view looking along lines 15—15 of FIG. 13 and illustrates the mounting plate 80 in a downward position. The actuator plate 84 has been translated downwardly where the plunger bar 90 is adjacent the barrel bar 88. FIG. 15 illustrates the actuator plate racks 132 extending through slots of the mounting plate 80 and their engagement with pinion gear 130 which has been turned by means of the actuator plate motor 126. The barrel 92 is now in a rinse well 28, for example. The plunger 94 has been forced down by means of the actuator plate 84 moving the plunger bar 90 to its lowermost position. Of course, the raised portion of the plate 22 has moved longitudinally with respect to the pipette assembly between the views of FIGS. 12 and 15.

FIG. 16 illustrates schematically the means by which the carriage mounting plate and plunger actuator bars are controlled to perform the automatic pipetting operation.

The dotted box 200 represents a microcomputer integrated circuit device, preferably a microcircuit No. HD68P01V07 manufactured by the Hitachi Corporation. The circuit includes a central processing unit 201A, a read only memory 201B, a random access memory 201C, a timer 201C, a timer 201D, an output interface circuit 201E and input interface circuit 201F. The read only memory circuit 201B includes stored software by which the entire automatic operation is controlled and will be discussed below.

FIG. 16 illustrates the carriage motor 40, the mounting plate 116 and the actuating plate motor 126 all under computer control via the motor driver circuits 202, 203, 204 such as circuits UDN-2952B manufactured by the Sprague Corporation. These motor driver circuits are used to control the speed of the motor and its direction of rotation. Also provided in conjunction with the motor are electronic break circuits 205, 206, 207 which are provided to quickly break the motor's rotation on receipt of a translation signal by the computer 200. Such electronic motor break circuits are preferably 2N6075 Triac circuits.

The position detector circuits 208 represent the circuitry with the trip switches 60 and 62 illustrated in FIG. 5 which indicate the position of the carriage 46 and the sample plate 16 with respect to the pipette assembly.

The position detector circuits 209 represent the circuitry associated with the lower trip switch 106 and the upper trip switch 105 which signal the upward or downward limits of travel of the mounting plate 80 with respect to the base.

The position detector circuits 210 represent the circuitry associated with trip switches 108 and 110 which indicate the relative position of the actuator plate 84 with respect to the mounting plate 80. The signals associated with each of those position detector circuits are represented as being carried by a bundle of electrical leads 215 to the input interface circuitry 201F of electronic module 200.

The alarm circuit 211 is provided for the apparatus, for example, such as a sounding device EAF14R06C manufactured by Panasonic. Such circuit is activated and a sound is generated to signal faults in the operation of the apparatus or to signal the readiness of the machine.

Indicator circuit 212 represents an indicator lamp as illustrated in FIG. 5 to signal the user that the power is on to the apparatus. The interlock circuit 213 represents the circuitry with sample plate interlock trip switch 65 which indicated the presence or absence of the sample plate on the carriage. Command circuit 214 represents a push button switch used to start or abort the automatic pipetting application process.

In operation, the central processing unit 201A receives the sequences of events instructions from the programs stored in the read only memory 201B. The central processing unit 201A then receives positional information concerning the moving mechanisms of the apparatus by means of reading and decoding the binary coded data present at the input interface 201F which receives information via leads 215 from the position detector circuits 208, 209, 210.

The microprocessor CPU 201A then receives an input command to start or abort the process by means of reading and decoding the binary coded data present at the input interface 201F which is connected to the command circuit 214 which may be the push button 214 illustrated in FIG. 5.

FIG. 17 illustrates in flow chart form the operations of the CPU 201A under program control. The CPU 201A determines the validity of a command to start the processing by means of reading and decoding the binary coded data present at the input interface 201F which receives a signal from the interlock circuit 213. This operation insures that the plate 16 is fully inserted into the carriage.

The CPU 201A causes the motors 40, 116 or 126 to turn in the required direction by means of writing the appropriate binary coded data to the output interface circuit 201E which is connected to the motor drive circuits 202, 203 and 204. The microprocessor CPU 201A then causes the mechanism movement to stop precisely when the required location is reached by writing the appropriate binary coded data to the output interface circuit 201E which is connected to the motor drive circuits 202, 203, 204 to disable the drive and then writing the appropriate binary coded data to the output interface 201E which is connected to the motor break circuits 205, 206, 207 to apply electronic breaking.

The microprocessor circuit 201A then signals that the pipetting apparatus is ready or that a plate has been complete or that a failure has occurred by means of writing the appropriate binary coded data to the output interface circuit 201E connected to the alarm circuit 211 to sound an alarm.

The timer 201D of FIG. 16 is used by the microprocessor CPU 201A to determine electrical or mechanical failures of the positioning mechanism. This is accomplished by means of measuring the elapsed time during a command to drive any motor. If the event is not completed within the prescribed length of time, the drive command is aborted and the alarm is activated by means of the microprocessor CPU 201A writing the appropriate binary coded data to the output interface connected to the alarm circuit 211. The timer 201D is also used to determine the repetition rate of the alarm thereby allowing the microprocessor circuit CPU 201A to encrypt and communicate to the operator the nature of the failure.

As shown in FIG. 17, once the automatic pipetting apparatus of the invention is running, a wide variety of different applications may be achieved. The sequence of

operations shown in FIG. 17 is preferred in that first, five microliters of cleansing agent such as distilled water is aspirated into the barrels of the pipettes from the wash well. Next, the water in the barrels is dispensed into the waste well. Then the applicator tips are dried by lowering them to a blotter pad as illustrated in FIG. 5.

Next, the barrels are moved to their upward position with the plungers in their downward position, the carriage is moved rearward and the barrels are lowered into the sample chambers 24. The plungers are raised thereby drawing a small amount of each sample of liquid, for example, patient blood to be tested. Where no dilution of the blood samples is desired, the samples are applied precisely to the cellulose acetate or agarose strip. The barrels are raised again. Again, the carriage is moved forward until the wash well is beneath the barrels and the mounting plate is lowered such that distilled water is again drawn into the barrels and then dispensed into the waste well.

Where dilution of the sample liquids is desired, the sample plate of FIG. 2B may be substituted for that of FIG. 2 and the computer program illustrated by the flow chart of FIG. 17 branches to the dilute routine. A preferred routine for diluting the samples is to draw an additional four micro liters of fluid from the wash well. This action results in each of the barrels being filled with four micro liters of diluting fluid (e.g, water) and one micro liter of blood (or other liquid) sample. Next the entire five micro liters of fluid of each barrel is applied to the respective dilution chambers of the dilution row of the plate of FIG. 2B. This process may be repeated a desired number of times to effect moving of the sample with the dilution fluid (water). Finally a one micro liter sample of the diluted blood sample is drawn into each barrel according to the description presented previously. The routine then proceeds as described above where the one micro liter of diluted liquid sample is applied to the support medium.

The dilution routine described above is preferred, but other routines may be used to effect good mixing of the blood sample with diluting liquid. For example, a first predetermined amount of liquid sample in each barrel may be applied to the dilution wells. A predetermined amount of wash liquid may then be applied to the dilution wells. After mixing the combination of the wash liquid and liquid sample of the dilution wells, (for example by the mixing technique described above), a small amount of liquid samples is aspirated from the dilution wells and applied to the support medium.

The appendix to this specification includes a source listing of the computer program written in HD68P01V07 Hitachi Assembly language which is stored in the read only memory 201B so as to automatically control the pipetting, cleansing, blotting, diluting (at the operator's option) and other functions described above.

Various modifications and alterations in the described structures will be apparent to those skilled in the art of the foregoing description which does not depart from the spirit of the invention. For this reason, these changes are desired to be included in the appended claims. The appended claims recite the only limitation to the present invention and the descriptive manner which is employed for setting forth the embodiments and is to be interpreted as illustrative and not limitative.

## APPENDIX TO SPECIFICATION

1					
2					
3					
4					
5					
6					
7					
8					
9	0000	P1DDR	EQU	\$0000	* Port 1 Data Dir. Register.
10	0001	P2DDR	EQU	\$0001	* Port 2 Data Dir. Register.
11					
12	0002	PORT1	EQU	\$0002	* Port 1 Data Register
13					
14					* Bit0= (P10) Carriage Tbrake
15					* Bit1= (P11) Not used
16					* Bit2= (P12) Tube Tbrake
17					* Bit3= (P13) Not used
18					* Bit4= (P14) Needle Tbrake
19					* Bit5= (P15) Needle Motor enable
20					* Bit6= (P16) Tube Motor enable
21					* Bit7= (P17) Carriage Motor enable
22					
23					
24	0003	PORT2	EQU	\$0003	* Port 2 Data Register
25					
26					* Bit0= (P20) Not used
27					* Bit1= (P21) Beeper output
28					* Bit2= (P22) Not used
29					* Bit3= (P23) Not used
30					* Bit4= (P24) Not used
31					
32	0004	P3DDR	EQU	\$0004	* Port 3 Data Dir. Register.
33	0005	P4DDR	EQU	\$0005	* Port 4 Data Dir. Register.
34					
35	0006	PORT3	EQU	\$0006	* Port 3 Data Register
36					
37					* BIT0= (P30) DIRECTION BIT FOR CRG MOTOR
38					* BIT1= (P31) DIRECTION BIT FOR CRG MOTOR
39					* BIT2= (P32) DIRECTION BIT FOR TUBES MOTOR
40					* BIT3= (P33) DIRECTION BIT FOR TUBES MOTOR
41					* BIT4= (P34) DIRECTION BIT FOR NEEDLES MOTOR
42					* BIT5= (P35) DIRECTION BIT FOR NEEDLES MOTOR
43					* BIT6= (P36) NOT USED
44					* Bit7= (P37) NOT USED
45					* SC1= Not used
46					* SC2= Not used
47					
48	0007	PORT4	EQU	\$0007	* Port 4 Data Register
49					
50					* Bit0= (P40) Home position for carrier
51					* Bit1= (P41) Home position for tubes
52					* Bit2= (P42) Home position for needles
53					* Bit3= (P43) Carrier position
54					* Bit4= (P44) Tubes position
55					* Bit5= (P45) Needle position
56					* Bit6= (P46) Not used
57					* Bit7= (P47) Not used
58					

```

59
60
61
62
63      0008      TCSREG    EQU    $0008      * Timer Control Stat
                                     us Reg.
64
65
66      * BIT0= (OLVL) POL of Port2-1 When Output Com
67                                     pare
68      * BIT1= (IEDG) Polarity of Capture Clock
69      * BIT2= (ETOI) Enable Overflow IRQ2
70      * BIT3= (EOCI) Enable Output Compare IRQ2
71      * BIT4= (EICI) Enable Input Capture IRQ
72      * BIT5= (TOF) Timer Overflow Flag
73      * BIT6= (OCF) Output Compare Flag
74      * BIT7= (ICF) Input Capture Flag
75      0009      FRCMSB    EQU    $0009      * Free Running Count
76                                     er MSB.
77      000A      FRCLSB    EQU    $000A      * Free Running Count
78                                     er LSB
79      000B      OCRMSB    EQU    $000B      * Output Capture Reg
80                                     MSB
81      000C      OCRLSB    EQU    $000C      * Output Compare Reg
82                                     LSB
83      000D      ICRMSB    EQU    $000D      * Input Capture Reg
84                                     MSB
85      000E      ICRLSB    EQU    $000E      * Input Capture Reg
86                                     LSB
87
88      *****
89      * PORT IRQ CONTROL REGISTER *
90      *****
91      000F      P3SREG    EQU    $000F      * Port 3 Status Reg.
92
93      * Bit0=
94      * Bit1=
95      * Bit2=
96      * Bit3= PORT3 Latch Enable
97      * Bit4= OSS (Output Strobe Sel.)
98      * Bit5=
99      * Bit6= IS3 IRQ1 Enable
100     * Bit7= IS3 Flag Bit
101
102     *****
103     * SERIAL PORT REGISTERS *
104     *****
105     0010      RMCREG    EQU    $0010      * Rate Mode Control
106                                     Reg
107
108     * Bit0= (SS0) Baud Rate Select
109     * Bit1= (SS1) Baud Rate Select
110     * Bit2= (CC0) Format CLK Source
111     * Bit3= (CC1) Format CLK Source
112     * Bit4=
113     * Bit5=
114     * Bit6=
115     * Bit7=
116     0011      TRCSRQ    EQU    $0011      * Xmit Recieve Contr
117                                     ol & Status
118
119     * Bit0= (WU) Wake-up
120     * Bit1= (TE) Xmit Enable
121     * Bit2= (TIE) Xmit IRQ2 Enable
122     * Bit3= (RE) Recv Enable
123     * Bit4= (RIE) Recv IRQ2 Ebable
124     * Bit5= (TDRE) Xmit Data Reg Empty Flag

```

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173

0012  
0013  
0014  
0080  
0040  
0008  
0002  
0004  
0004  
0010  
00F3  
0080  
0002  
0001  
0001  
0001  
0008  
00FC  
0020  
0020  
0004

```

* Bit6= (ORDE) Overrun Framing Error
* Bit7= (RDRF) Recieve Data Reg Full

RCVREG EQU $0012 * Receive Data Register
XMTREG EQU $0013 * Transmit Data Register

*****
* RAM AND EPROM CONTROL REGISTERS *
*****

RAMROM EQU $0014 * Ram Eprom Control Reg.

* Bit0= (PLC) Programing Latch Control
* Bit1= (PPC) Programing Power Control
* Bit2=
* Bit3=
* Bit4=
* Bit5=
* Bit6= (RAME) Enable Ram Addressing
* Bit7= (STBY PWR) Standby Power Status Flag
**** $0015-$001F RESERVED ! ****

*****
* STANDBY RAM ($0080-$00BF) *
*****

*****
* TEMPORARY RAM ($00A0-$00FF) *
*****

IRQMSK EQU $80 * DEBOUNCE MASK START SWITCH

TUBEENB EQU $40 *TUBE DRIVE ENABLE
TUBEMOTP EQU $08 *TUBE MOTOR DRIVE POSITIVE.
TUBESW1 EQU $02 *TUBE HOME SWITCH.
TUBETBRK EQU $04 *TUBE TRIAC BRAKE
TUBEMOTN EQU $04 *TUBE MOTOR DRIVE NEGATIVE.
TUBESW2 EQU $10 *TUBE DOWN POSITION SWITCH.
TUBEMSK EQU $F3 *MASKS OFF THE TUBE DIRECTION BITS TO A 0.

CRGENB EQU $80 *CARRIAGE DRIVE ENABLE
CRGMOTP EQU $02 *CARRIAGE MOTOR DRIVE POSTIVE.
CRGSW1 EQU $01 *CARRIAGE HOME POSITION SWITCH.
CRCTBRK EQU $01 *CARRIAGE TRIAC BRAKE
CRGMOTN EQU $01 *CARRIAGE MOTOR DRIVE NEGATIVE.
CRGSW2 EQU $08 *CARRIAGE LOCATION SWITCH.
CRCMSK EQU $FC *MASKS OFF THE CRC DIRECTION BIT TO A 0.

NDLENB EQU $20 *MASK OFF THE NEEDLE DIRECTION BITS TO A 0
NDLMOTP EQU $20 *NEEDLE MOTOR DRIVE POSTIVE.
NDLSW1 EQU $04 *NEEDLE HOME POSITIO
    
```

174	0010	NDLTERK	EQU	\$10
175	0010	NDLMOTN	EQU	\$10
176	0020	NDLSW2	EQU	\$20
177	00CF	NDLMSK	EQU	\$CF
178				
179	0003	CLEANYET	EQU	\$03
180	0040	TRAY	EQU	\$40
181	0001	WASH	EQU	\$01
182	0002	WASTE	EQU	\$02
183	0003	BLOT	EQU	\$03
184	0004	SAMPWELL	EQU	\$04
185	0005	DULUTER	EQU	\$05
186	0006	PLATE	EQU	\$06
187	0001	NDL1UL	EQU	\$01
188	0002	NDLSUL	EQU	\$02
189	0001	ERROR1	EQU	\$01
190	0002	ERROR2	EQU	\$02
191	0003	ERROR3	EQU	\$03
192	0004	ERROR4	EQU	\$04
193	0004	ETO1	EQU	\$04
194	00FF	STACK	EQU	\$FF
195	0015	ALLBRAKE	EQU	\$15
196	00E0	ALLENB	EQU	\$E0
197	0002	BRAKEPRT	EQU	PORT1
198	000F	SWBOUNCE	EQU	\$0F
199	5000	JOCTIME	EQU	\$5000
200	02FF	TONE1	EQU	\$02FF
201	04FF	TONE2	EQU	\$04FF
202	08FF	TONE3	EQU	\$08FF
203	0FFF	TONE4	EQU	\$0FFF
204	1FFF	TONE5	EQU	\$1FFF
205	1FFF	TONE	EQU	\$1FFF
206	0007	SWPRT	EQU	PORT4
207	0006	MOTORPRT	EQU	PORT3
208	00FF	OFFSW	EQU	\$00FF
209	00AF	SOAKTIME	EQU	\$00AF
210	0010	BLOTIME	EQU	\$0010
211	0080		ORG	\$0080
212	0080	WASHTIMS	RMB	1
213	0081	TONES	RMB	2
214	0083	WATCHDOG	RMB	1
215	0084	ENABLE	RMB	1
216	0085	DIRECT	RMB	1
217	0086	SWITCH	RMB	1
218	0087	TBRAKE	RMB	1

N SWITCH.  
 \*NEEDLE TRIAC BRAKE  
 \*NEEDLE MOTOR DRIVE  
 NEGATIVE.  
 \*NEEDLE LOCATION SWI  
 TCH.  
 \*MASK OFF THE NDL DI  
 RECTION BIT TO A 0.  
 \*HOW MANY TIMES TO C  
 YCLE THROUGH THE WAS  
 H CYCLE.  
 \*TO MAKE SURE THE TR  
 AY IS ALL THE IN.  
 \*CARRIAGE LOCATION O  
 NE.  
 \*CARRIAGE LOCATION T  
 WO.  
 \*CARRIAGE LOCATION T  
 HREE.  
 \*CARRIAGE LOCATION F  
 OUR.  
 \*CARRIAGE LOCATION F  
 IVE.  
 \*NEEDLE LOCATION ONE  
 \*NEEDLE LOCATION TWO  
 \*TUBES NOT AT HOME P  
 OSITION.  
 \*MOTOR NOT DRIVING.  
 \*TRAY IS NOT ALL THE  
 WAY IN.  
 \*TIMER OVERFLOW FLAG  
 IN THE TCSREG.  
 \*TOP OF RAM.  
 \*ALL MOTOR ENABLE  
 \*WAITING FOR TUBE SW  
 ITCH TO STOP BOUNCIN  
 G.  
 \*TUBE HOME POS. ERRO  
 R TONE.  
 \*MOTOR NOT REACHING  
 LIMIT SWITCH TONE  
 \*TRAY NOT IN TONE.  
 \*SWITCH NOT CLOSED E  
 RROR.  
 \*UNKNOWN ERROR.  
 \*READY FOR OPERATION  
 TONE.  
 \*SWITCH PORT, PORT4  
 \*MOTOR PORT, PORT3  
 \*PAUSE TIME.  
 \* MOTOR CONTROL BLOC  
 K ENABLE  
 \* MOTOR CONTROL BLOC  
 K DIRECTION  
 \* MOTOR CONTROL BLOC  
 K SWITCH  
 \* MOTOR CONTROL BLOC

```

219      0088
220      0089
221      008A
222      008B
223      008C
224
225
226
227
228
229
230
231
232
233
234
235
236
237 245R 008D
238
239
240
241
242
243
244
245
246
247
248
249
250 490 008D
251
252      F800
253  2R F800 0F
254   8 F801 7F 008B
255  14 F804 7F 008C
256  16 F807 86 02
257  20 F809 97 01
258  22 F80B 4F
259  26 F80C 97 08
260  28 F80E 43
261  30 F80F C6 E0
262  32 F811 53
263  36 F812 97 00
264  40 F814 D7 02
265  44 F816 97 04
266  47 F818 CE 7FFF
267   6R F81B 7F 0006
268   8 F81E C6 E0
269  11 F820 DA 02
270  15 F822 D7 02
271  18 F824 8E 00FF
272  22 F827 09
273  26 F828 26 F1      (F81B)
274   2R F82A 0E
275  11 *F82B BD F9C9
276  20 *F82E BD F9E3
277  29 *F831 BD FA12
278  38 *F834 BD FB15
279  44 F837 7F 0080
280  46 F83A 86 B0
281  51 F83C B7 008B
282  60 F83F 3E
    
```

```

MASK      RMB      1
CRGPOS    RMB      1
NDLPOS    RMB      1
STATUS    RMB      1
COUNT    RMB      1
*****
&L        MAC      START
          LDAA     ENABLE
          COMA
          ANDA     BRAKEPRT
          STAA     BRAKEPRT * DISABLE DRIVE
          LDAA     MASK
          ANDA     MOTORPRT * ZERO DIRECTION BITS
          ORAA     DIRECT * GET REQUIRED DIRECTION
          STAA     MOTORPRT
          LDAA     ENABLE
          ORAA     BRAKEPRT
          STAA     BRAKEPRT * ENABLE
          MEN
&L        MAC      STOP
          LDAA     ENABLE
          COMA
          ANDA     BRAKEPRT * DISABLE DRIVE
          ORAA     TBRAKE * TRIAC BRAKE
          STAA     BRAKEPRT * BRAKE AND DISABLE
          LDAA     MASK
          ANDA     MOTORPRT
          STAA     MOTORPRT * DRIVE FAST STOP
          LDAA     ENABLE
          ORAA     BRAKEPRT
          STAA     BRAKEPRT * DRIVE FAST STOP
          MEN
*****
INIT      ORC      *F800
          SEI
          CLR      STATUS
          CLR      COUNT
          LDAA     *$02
          STAA     P2DDR *MAKES P21 AN OUTPUT
          CLRA
          STAA     TCSREG
          COMA
          LDAB     *ALLENB
          COMB
          STAA     P1DDR * PORT 1 ALL OUTPUT
          STAB     BRAKEPRT * SET ALL TRIAC BRAKE, DISABLE DRIVE
          STAA     P3DDR * PORT 3 ALL OUTPUT
          LDX     *$7FFF
          CLR      MOTORPRT * MOTOR DRIVES FAST STOP
          LDAB     *ALLENB
          ORAB     BRAKEPRT
          STAB     BRAKEPRT * ENABLE DRIVE FOR FAST STOP
          LDS     *STACK
          DEX
          BNE     !1
          CLI
          JSR     TUBEHOME
          JSR     CRGHOME
          JSR     NDLHOME
          JSR     BEEPER
          CLR     WASHTIMS
          LDAA     *$80
          STAA     STATUS * Mode READY
          WAI
    
```

K TRIAC BRAKE  
\* MOTOR CONTROL DIRECTION BIT MASK

\* Mode Flag

\* DISABLE DRIVE

\* ZERO DIRECTION BITS

\* GET REQUIRED DIRECTION

\* ENABLE

\* DISABLE DRIVE

\* TRIAC BRAKE

\* BRAKE AND DISABLE

\* DRIVE FAST STOP

\* DRIVE FAST STOP

\*MAKES P21 AN OUTPUT

\* PORT 1 ALL OUTPUT

\* SET ALL TRIAC BRAKE, DISABLE DRIVE

\* PORT 3 ALL OUTPUT

\* MOTOR DRIVES FAST STOP

\* ENABLE DRIVE FOR FAST STOP

\*STACK

!1

TUBEHOME

CRGHOME

NDLHOME

BEEPER

WASHTIMS

\*\$80

\* Mode READY

```

283 2R F840 C6 E0
284 4 F842 53
285 8 F843 D7 02

286 14 F845 7F 0006

287 16 F848 C6 E0
288 19 F84A DA 02
289 23 F84C D7 02

290 3R F84E CE 00FF
291 3R F851 96 07
292 5 F853 84 80
293 9 F855 27 F7 (F84E)
294 4R F857 09
295 8 F858 26 F7 (F851)
296
297 6R F85A 7D 008B
298 10 F85D 26 01 (F860)

299 20 F85F 3B
300 24 F860 2B 03 (F865)

301 3R F862 7E F800

302 2R F865 86 7F
303 7 F867 B7 008B
304 9 F86A 0E
305 12 F86B 8E 00FF
306 14 F86E C6 01
307 23 *F870 BD FAB7
308 32 *F873 BD F9D6
309 34 F876 C6 02
310 43 *F878 BD FAE6
311 52 *F87B BD F9C9
312 54 F87E C6 02
313 63 *F880 BD FAB7
314 72 *F883 BD FA12
315 81 *F886 BD F9D6
316 90 *F889 BD F9C9
317 92 F88C C6 03
318 101 *F88E BD FAB7
319 110 *F891 BD F9D6
320 119 *F894 BD FC33

321 128 *F897 BD F9C9
322 130 F89A C6 04
323 139 *F89C BD FAB7
324 148 *F89F BD F9D6
325 150 F8A2 C6 01
326 159 *F8A4 BD FAE6
327 168 *F8A7 BD F9C9
328 170 F8AA C6 03
329 179 *F8AC BD FAB7
330 188 *F8AF BD FA12
331 197 *F8B2 BD F9D6
332 206 *F8B5 BD FC33
333 215 *F8B8 BD F9C9
334 217 F8BB C6 04
335 226 *F8BD BD FAB7
336 235 *F8C0 BD F9D6
337 237 F8C3 C6 01
338 246 *F8C5 BD FAE6
339 255 *F8C8 BD F9C9
340 258 F8CB 96 06
341 260 F8CD 84 50
342 264 F8CF 26 3B (F90C)
343 2R F8D1 C6 01
344 11 *F8D3 BD FAB7
345 20 *F8D6 BD F9D6
346 22 F8D9 C6 02
347 31 *F8DB BD FAE6

```

EXEC

```

LDAB #ALLENB
COMB
STAB BRAKEPRT

```

CLR MOTORPRT

```

LDAB #ALLENB
ORAB BRAKEPRT
STAB BRAKEPRT

```

17

```

LDX #OFFSW
LDAA SWPRT
ANDA #IRQMSK
BEQ 17
DEX
BNE 14

```

14

```

TST STATUS
BNE 12

```

12

```

RTI
BMI 13

```

JMP INIT

13

```

LDAA #*7F
STAA STATUS
CLI

```

```

LDS #STACK
LDAB #WASH
JSR CRGLOC
JSR TUBEDOWN
LDAB #NDLSUL
JSR NDLLC
JSR TUBEHOME
LDAB #WASTE
JSR CRGLOC
JSR NDLLC
JSR TUBEDOWN
JSR TUBEHOME
LDAB #BLOT
JSR CRGLOC
JSR TUBEDOWN
JSR BLOTTER

```

```

*THE TIME THE TUBES
WILL STAY DOWN.

```

```

JSR TUBEHOME
LDAB #SAMPWELL
JSR CRGLOC
JSR TUBEDOWN
LDAB #NDL1UL
JSR NDLLC
JSR TUBEHOME
LDAB #BLOT
JSR CRGLOC
JSR NDLLC
JSR TUBEDOWN
JSR BLOTTER
JSR TUBEHOME
LDAB #SAMPWELL
JSR CRGLOC
JSR TUBEDOWN
LDAB #NDL1UL
JSR NDLLC
JSR TUBEHOME
LDAA MOTORPRT
ANDA #80
BNE 110
LDAB #WASH
JSR CRGLOC
JSR TUBEDOWN
LDAB #NDLSUL
JSR NDLLC

```

```

*SETS THE TRIAC BRAKES,
AND DISENABLES THE MOTORS.

```

```

*MOTOR DRIVERS FAST STOP.

```

```

*ENABLES MOTOR DRIVERS FOR FAST STOP.

```

```

* If Not = 0 Not INITIAL Mode

```

```

* If -. READY Mode so go RUN

```

```

* If + RUN Mode so go INIT

```

```

* Flag RUN mode

```





416 13 F993 B6 0084  
 416 15 F996 43  
 416 18 F997 94 02  
 416 22 F999 97 02  
 416 26 F99B B6 0088  
 416 29 F99E 94 06  
  
 416 33 F9A0 BA 0085  
  
 416 37 F9A3 97 06  
 416 41 F9A5 B6 0084  
 416 44 F9AB 9A 02  
 416 48 F9AA 97 02  
 417 4R F9AC 09  
 418 8 F9AD 26 FD (F9AC)  
 419 F9AF  
 419 4R F9AF B6 0084  
 419 6 F9B2 43  
 419 9 F9B3 94 02  
 419 13 F9B5 BA 0087  
 419 17 F9B8 97 02  
 419 21 F9BA B6 0088  
 419 24 F9BD 94 06  
 419 28 F9BF 97 06  
 419 32 F9C1 B6 0084  
 419 35 F9C4 9A 02  
 419 39 F9C6 97 02  
 420 44 F9C8 39  
 421 2R F9C9 C6 01  
 422 5 F9CB CE F9D1  
 423 8 F9CE 7E FB69  
 424 F9D1 40  
 425 F9D2 08  
 426 F9D3 02  
 427 F9D4 04  
 428 F9D5 F3  
 429 2R F9D6 C6 01  
 430 5 F9DB CE F9DE  
 431 8 F9DB 7E FB66  
 432 F9DE 40  
 433 F9DF 04  
 434 F9E0 10  
 435 F9E1 04  
 436 F9E2 F3  
 437 6R F9E3 7F 0089  
 438 15 \*F9E6 BD FA2D  
 439 18 F9E9 CE F9F1  
 440 20 F9EC C6 01  
 441 23 F9EE 7E FB66  
 442 F9F1 80  
 443 F9F2 02  
 444 F9F3 01  
 445 F9F4 01  
 446 F9F5 FC  
 447 9R \*F9F6 BD FA2D  
 448 12 F9F9 CE F9FF  
 449 15 F9FC 7E FB66  
 450 F9FF 80  
 451 FA00 01  
 452 FA01 08  
 453 FA02 01  
 454 FA03 FC  
 455 9R \*FA04 BD FA2D  
 456 12 FA07 CE FA0D  
 457 15 FA0A 7E FB66  
 458 FA0D 80  
 459 FA0E 02  
 460 FA0F 08  
 461 FA10 01  
 462 FA11 FC  
 463 6R FA12 7F 008A

+ LDAA ENABLE  
 + COMA  
 + ANDA BRAKEPRT  
 + STAA BRAKEPRT \* DISABLE DRIVE  
 + LDAA MASK  
 + ANDA MOTORPRT \* ZERO DIRECTION BIT  
 S  
 + ORAA DIRECT \* GET REQUIRED DIREC  
 TION  
  
 + STAA MOTORPRT  
 + LDAA ENABLE  
 + ORAA BRAKEPRT  
 + STAA BRAKEPRT \* ENABLE  
 !1 DEX  
 BNE !1  
 STOP  
 LDAA ENABLE  
 COMA  
 ANDA BRAKEPRT \* DISABLE DRIVE  
 ORAA TBRAKE \* TRIAC BRAKE  
 STAA BRAKEPRT \* BRAKE AND DISABLE  
 LDAA MASK  
 ANDA MOTORPRT  
 STAA MOTORPRT \* DRIVE FAST STOP  
 LDAA ENABLE  
 ORAA BRAKEPRT  
 STAA BRAKEPRT \* DRIVE FAST STOP  
 RTS  
 TUBEHOME LDAB ##01  
 LDX #!1  
 JMP DRIVE!9  
 !1 FCB TUBEENB  
 FCB TUBEMOTP  
 FCB TUBESW1  
 FCB TUBETBRK  
 FCB TUBEMSK  
 TUBEDOWN LDAB ##01  
 LDX #!1  
 JMP DRIVE  
 !1 FCB TUBEENB  
 FCB TUBEMOTN  
 FCB TUBESW2  
 FCB TUBETBRK  
 FCB TUBEMSK  
 CRGHOME CLR CRGPOS  
 JSR CHECKTUB  
 LDX #!1  
 LDAB ##01  
 JMP DRIVE  
 !1 FCB CRGENB  
 FCB CRGMOTP  
 FCB CRGSW1  
 FCB CRGTBRK  
 FCB CRGMSK  
 CRGBACK JSR CHECKTUB  
 LDX #!1  
 JMP DRIVE  
 !1 FCB CRGENB  
 FCB CRGMOTN  
 FCB CRGSW2  
 FCB CRGTBRK  
 FCB CRGMSK  
 CRGFRONT JSR CHECKTUB  
 LDX #!1  
 JMP DRIVE  
 !1 FCB CRGENB  
 FCB CRGMOTP  
 FCB CRGSW2  
 FCB CRGTBRK  
 FCB CRGMSK  
 NDHOME CLR NDLP0S



Line	Count	Label	Address	Hex	Comment	Instruction	Value
525	15	FAA6	20	E4	(FA8C)	BRA	!2
526	3R	FAA8	CE	00AF		LDX	#SOAKTIME
527	3R	FAAB	96	08		LDAA	TCSREG
528	6	FAAD	D6	09		LDAB	FRCMSB
529	8	FAAF	84	20		ANDA	##20
530	12	FAB1	27	F8	(FAAB)	BEQ	!1
531	4R	FAB3	09			DEX	
532	8	FAB4	26	F5	(FAAB)	BNE	!1
533	13	FAB6	39			RTS	
534	2R	FAB7	17			TBA	
535	6	FAB8	F0	0089		SUBB	CRGPOS
536	10	FABB	24	15	(FAD2)	BCC	!1
537	2R	FABD	50			NEGB	
538	7	FABE	B7	0089		STAA	CRGPOS
539	9	FAC1	86	01		LDAA	#CRGSW1
540	12	FAC3	94	07		ANDA	SWPRT
541	16	FAC5	27	08	(FACF)	BEQ	!2
542	2R	FAC7	86	08		LDAA	#CRGSW2
543	5	FAC9	94	07		ANDA	SWPRT
544	9	FACB	26	02	(FACF)	BNE	!2
545	2R	FACD	CB	01		ADDB	##01
546	3R	FACF	7E	FA04		JMP	CRGFRONT
547	5R	FAD2	B7	0089		STAA	CRGPOS
548	7	FAD5	86	01		LDAA	#CRGSW1
549	10	FAD7	94	07		ANDA	SWPRT
550	14	FAD9	27	08	(FAE3)	BEQ	!3
551	2R	FADB	86	08		LDAA	#CRGSW2
552	5	FADD	94	07		ANDA	SWPRT
553	9	FADF	26	02	(FAE3)	BNE	!3
554	2R	FAE1	CB	01		ADDB	##01
555	3R	FAE3	7E	F9F6		JMP	CRGBACK
556	2R	FAE6	17			TBA	
557	6	FAE7	F0	008A		SUBB	NDLPOS
558	10	FAEA	24	15	(FB01)	BCC	!1
559	2R	FAEC	50			NEGB	
560	7	FAED	B7	008A		STAA	NDLPOS
561	9	FAF0	86	04		LDAA	#NDLSW1
562	12	FAF2	94	07		ANDA	SWPRT
563	16	FAF4	27	08	(FAFE)	BEQ	!2
564	2R	FAF6	86	20		LDAA	#NDLSW2
565	5	FAF8	94	07		ANDA	SWPRT
566	9	FAFA	26	02	(FAFE)	BNE	!2
567	2R	FAFC	CB	01		ADDB	##01
568	3R	FAFE	7E	FA12		JMP	NDLHOME
569	5R	FB01	B7	008A		STAA	NDLPOS
570	7	FB04	86	04		LDAA	#NDLSW1
571	10	FB06	94	07		ANDA	SWPRT
572	14	FB08	27	08	(FB12)	BEQ	!3
573	2R	FB0A	86	20		LDAA	#NDLSW2
574	5	FB0C	94	07		ANDA	SWPRT
575	9	FB0E	26	02	(FB12)	BNE	!3
576	2R	FB10	CB	01		ADDB	##01
577	3R	FB12	7E	FA22		JMP	NDL1UL5
578	3R	FB15	CE	1FFF		LDX	#TONE
579	3R	FB18	D6	08		LDAB	TCSREG
580	5	FB1A	C5	40		BITB	##40
581	9	FB1C	27	FA	(FB18)	BEQ	!1
582	2R	FB1E	CB	01		EORB	##01
583	6	FB20	D7	08		STAB	TCSREG
584	9	FB22	D6	0C		LDAB	OCRLSB
585	11	FB24	CB	C8		ADDB	##C8
586	15	FB26	D7	0C		STAB	OCRLSB
587	18	FB28	D6	08		LDAB	OCRMSB
588	20	FB2A	C9	00		ADCB	##00
589	24	FB2C	D7	08		STAB	OCRMSB
590	28	FB2E	09			DEX	
591	32	FB2F	26	E7	(FB18)	BNE	!1
592	3R	FB31	D6	08		LDAB	TCSREG
593	5	FB33	84	FE		ANDA	##FE
594	9	FB35	D7	08		STAB	TCSREG
595	14	FB37	39			RTS	

SOAK

!1

(FAAB)

(FAAB)

CRGLOC

(FAD2)

(FACF)

(FACF)

!2

!1

(FAE3)

(FAE3)

!3

NDLLOC

(FB01)

(FAFE)

(FAFE)

!2

!1

(FB12)

(FB12)

!3

BEEPER

!1

(FB18)

(FB18)





691 11 FC4E 39  
 692 FFF0  
 693 FFF0 F800  
 694 FFF2 FA44  
 695 FFF4 F800  
 696 FFF6 F800  
 697 FFF8 F840  
 698 FFFA F800  
 699 FFFC F800  
 700 FFFE F800  
 701 0000

RTS  
 ORC \$FFF0  
 FDB INIT \* SCI OF THE TCSREG.  
 FDB UPDATIME \* TIMER OVERFLOW BIT  
 FDB INIT \* OCI OF THE TCSREG.  
 FDB INIT \* ICI OF THE TCSREG.  
 FDB EXEC \* IRQ  
 FDB INIT \* SWI  
 FDB INIT \* NMI  
 FDB INIT \* RESET  
 END

NO ERRORS DETECTED

0015 ALLBRAKE	195												
00E0 ALLENB	196	261	268	283	287								
FB15 BEEPER	578	278	514										
FB38 BEEPERRO	596	489	502	673									
0003 BLOT	183	317	328	371	394	401							
0010 BLOTIME	210	676											
FC33 BLOTTER	676	320	332	374	408	509							
0002 BRAKEPRT	197	264	269	270	285	288	289	416	416	416	416		
		416	419	419	419	419	496	496	496	496	496		
		636	636	636	636	643	643	643	643	643	655		
		655	655	655	686	687							
FC42 BRAKOFF	684	415	626										
FA2D CHECKTUB	479	438	447	455									
0003 CLEANYET	179	411											
008C COUNT	223	255	518	520	523								
F9F6 CRGBACK	447	555											
0080 CRGENB	163	442	450	458									
FA04 CRCFRONT	455	546											
F9E3 CRGHOME	437	276											
FAB7 CRGLOC		307	313	318	323	329	335	344	350	366			
	534	372	377	383	395	402							
0001 CRGMOTN	167	403	451										
0002 CRGMOTP	164	397	443	459									
00FC CRCMSK	169	446	454	462									
0089 CRGPOS	220	437	535	538	547								
0001 CRGSW1	165	444	539	548									
0008 CRGSW2	168	452	460	542	551								
0001 CRGTBRK	166	445	453	461									
0085 DIRECT	216	398	404	416	619	636	643						
FB66 DRIVE	614	423	431	441	449	457	466	473					
0005 DULUTER	185	349											
0084 ENABLE	215	416	416	419	419	496	496	617	636	636			
		643	643	655	655								
0001 ERROR1	189	488	596										
0002 ERROR2	190	501	600										
0003 ERROR3	191	604											
0004 ERROR4	192	608	672										
0004 ETOI	193	629											
FB40 EXEC	283	697											
FAB9 FLASH	513	599	603	607	611	613							
000A FRCLSB	75												
0009 FRCMSB	74	528	678										
000E ICRLSB	81												
000D ICRMSB	80												
F800 INIT	253	301	414	693	695	696	698	699	700				
0080 IRQMSK	153	292											
F990 JOG	415	399	406										
5000 JOGTIME	199	396	405										
0088 MASK	219	416	419	496	625	636	643	655					
0006 MOTORPRT	207	267	286	340	416	416	419	419	496	496			
		636	636	643	643	655	655						
0001 NDL1UL	187	325	337	362									
FA22 NDL1UL5	472	577											
0002 NDL5UL	188	309	346	353	356	359	379	510					





What is claimed is:

1. Automatic pipetting apparatus comprising a base,

sample plate means disposed on said base, said sample plate means having longitudinal and lateral dimensions, said plate means including a lateral row of liquid sample chambers and a lateral application space longitudinally separated from said liquid chamber row, said lateral application space adapted to receive a microporous support medium, said sample chambers adapted to receive liquid samples,

a pipette frame including vertical support means for supporting said frame from said base laterally above said sample plate means, said pipette frame having a longitudinal position with respect to said longitudinal dimension of said sample plate means, longitudinal translation means for changing the longitudinal position between said pipette frame and said sample plate means,

a mounting plate carried by said pipette frame, vertical translation means for effecting relative vertical movement of said mounting plate and said sample plate means,

a plurality of microsyringe barrels having their heads secured in a row to said mounting plate, said barrels spaced corresponding to the spacing of said liquid chambers on said plate, said barrels being hollow with each having a lower tip,

a plurality of micro-plungers, each of said plungers disposed in one of said barrels,

plunger translation means for moving said plungers vertically within said barrels,

signalling means

for generating longitudinal signals representative of the relative longitudinal orientation of said pipette frame with respect to said sample plate means,

for generating mounting plate signals representative of the vertical orientation of said mounting plate relative to said sample plate means and

for generating plunger signals representative of the orientation of said plungers relative to said barrels, and

programmed computer means responsive to said longitudinal signals, to said mounting plate signals and to said plunger signals for generating a sequence of control signals to said longitudinal translation means, to said vertical translation means and to said plunger translation means to aspirate a first predetermined amount of liquid from said sample chambers into said respective pipette barrels, and to apply a droplet of said liquid samples in each of said pipette barrels onto corresponding spaces of said microporous support medium when placed on said lateral application space of said sample plate by precisely positioning said lower tips of said barrels at a small distance above said microporous support medium, said small distance being smaller than the diameter of a droplet of liquid sample which may be maintained on the end of said tips through surface tension forces of the barrel tips, whereby each droplet slightly touches said microporous support medium and is thereby relieved of its surface tension and is precisely transferred to said microporous support medium from each of said pipette barrels.

2. The apparatus of claim 1 wherein

said sample plate means is translated longitudinally beneath said pipette frame by said longitudinal translation means.

3. The apparatus of claim 1 wherein said pipette frame is translated longitudinally above said sample plate means by said longitudinal translation means.

4. The apparatus of claim 1 wherein said sample plate means includes a wash well adapted to contain wash liquid and a waste well longitudinally spaced from each other and from said sample chambers,

said programmed computer means generating a further sequence of control signals to said longitudinal translation means, to said vertical translation means and to said plunger translation means before aspirating liquid from said sample chambers,

to draw a second predetermined amount of wash liquid from said wash well into respective pipette barrels, and

to discharge said wash liquid into said waste well.

5. The apparatus of claim 1 wherein said sample plate means further includes a wash well adapted to contain wash liquid and a waste well longitudinally spaced from each other and from said sample chambers and a row of individual liquid dilution wells longitudinally spaced from said sample chambers, said dilution wells adapted to receive dilution liquid,

said programmed computer means generating a further sequence of control signal to said longitudinal translation means, to said vertical translation means and to said plunger translation means after aspirating liquid samples of said liquid samples into said pipette barrels,

to aspirate a second predetermined amount of wash fluid from said wash well into said respective pipette barrels operably creating a combination of sample liquid and wash liquid in each barrel,

to discharge said sample liquid/wash liquid into said corresponding dilution wells operably creating diluted liquid samples, and

to aspirate a third predetermined amount of diluted liquid samples from said dilution wells into said respective pipette barrels.

6. The apparatus of claim 5 wherein

said programmed computer means generates a further sequence of control signals to said plunger translation means to alternately discharge said sample liquid/wash liquid into said corresponding dilution wells and aspirate a predetermined amount of diluted liquid from said dilution wells into said respective pipette barrels operatively causing mixing of said liquid samples with said dilution liquid in said dilution wells.

7. The apparatus of claim 4 wherein said sample plate means further includes a row of individual liquid dilution wells longitudinally spaced from said sample chambers, said dilution wells adapted to receive dilution liquid,

said programmed computer means generating a further sequence of control signals to said longitudinal translation means, to said vertical translation means and to said plunger translation means for applying said first predetermined amount of liquid sample in each barrel to said dilution wells, applying a third predetermined amount of wash liquid from each barrel to said dilution wells, mixing the combination of said wash liquid and said liquid sample of said dilution wells, and aspirating an amount of

diluted liquid samples from said dilution wells into said respective pipette barrels.

8. Automatic pipetting apparatus comprising a base, sample plate means disposed on said base, said sample plate means having longitudinal and lateral dimensions, said plate means including a lateral row of liquid sample chambers and a lateral application space longitudinally separated from said liquid chamber row, said lateral application space adapted to receive a microporous support medium, said sample chambers adapted to receive liquid samples,

a pipette frame including vertical support means for supporting said frame from said base laterally above said sample plate means, said pipette frame having a longitudinal position with respect to said longitudinal dimension of said sample plate means, longitudinal translation means for changing the relative longitudinal position between said pipette frame and said sample plate means,

a mounting plate carried by said pipette frame, vertical translation means for effecting relative vertical movement of said mounting plate and said sample plate means,

a plurality of microsyringe barrels having their heads secured in a row to said mounting plate, said barrels spaced corresponding to the spacing of said liquid chambers on said plate, said barrels being hollow with each having a lower tip,

a plurality of micro-plungers, each of said plungers disposed in one of said barrels,

plunger translation means for moving said plungers vertically within said barrels,

signalling means

for generating longitudinal signals representative of the relative longitudinal orientation of said pipette frame with respect to said sample plate means,

for generating mounting plate signals representative of the vertical orientation of said mounting plate relative to said sample plate means and

for generating plunger signals representative of the orientation of said plungers relative to said barrels, and

programmed computer means responsive to said longitudinal signals, to said mounting plate signals and to said plunger signals for generating a sequence of control signals to said longitudinal translation means, to said vertical translation means and to said plunger translation means to aspirate a first predetermined amount of liquid from said sample chambers into said respective pipette barrels, and to apply said liquid samples in each of said pipette barrels, where said lower tips of said barrels are at a position slightly above said microporous support medium onto corresponding spaces of said microporous support medium when placed on said lateral application space of said sample plate,

wherein said sample plate means includes a wash well adapted to contain wash liquid and a waste well longitudinally spaced from each other and from said sample chambers,

said programmed computer means generating a further sequence of control signals to said longitudinal translation means, to said vertical translation means and to said plunger translation means before aspirating liquid from said sample chambers,

to draw a second predetermined amount of wash liquid from said wash well into respective pipette barrels, and

to discharge said wash liquid into said waste well, and wherein said sample plate means includes a longitudinal blotting space for applying a lateral blotting paper strip, said blotting space longitudinally separated from said sample chambers row, said wash well, said waste well and said lateral application space, and

said programmed computer means generating a further sequence of control signals to said longitudinal translation means, to said vertical translation means and to said plunger translation means after discharging said rinse liquid into said waste well, to blot the tips of said barrels on said blotting paper strip.

9. A sample plate adapted for use with automatic pipetting apparatus comprising a lateral row of individual liquid sample chambers and a lateral application space longitudinally separated from said liquid chamber row, said lateral application space adapted to receive a microporous support medium and

including a raised portion and a lower portion, said row of individual liquid sample chambers being disposed on said raised portion, said lateral application space being disposed on said lower portion and further comprising a wash well and a waste well longitudinally spaced from each other and from said sample chambers.

10. The sample plate of claim 9 further comprising a row of individual liquid dilution wells longitudinally spaced from said sample chambers.

11. A sample plate adapted for use with automatic pipetting apparatus comprising a lateral row of individual liquid sample chambers and a lateral application space longitudinally separated from said liquid chamber row, said lateral application space adapted to receive a microporous support medium, and

further comprising a wash well and a waste well longitudinally spaced from each other and from sample chambers, and

further including a longitudinal blotting space for applying a lateral blotting paper strip, said blotting space longitudinally separated from said sample chamber row, said wash well, said waste well and said lateral application space.

12. The sample plate of claim 11 including a raised portion and a lower portion, said row of individual liquid sample chambers being disposed on said raised portion, said lateral application space being disposed on said lower portion.

13. The sample plate of claim 11 including a raised portion and a lower portion, said row of individual liquid sample chambers, said wash well and said waste well being disposed on said raised portion, said lateral application space and said blotting space being disposed on said lower portion.

14. Automatic pipetting apparatus comprising,

a base,

track means disposed longitudinally on said base,

a carriage longitudinally movably disposed on said track means,

a sample plate removably disposed on said carriage, said sample plate including a lateral row of individual liquid sample chambers and a lateral application space longitudinally separated from said liquid chamber row, said lateral application space adapted to receive a microporous support medium, said sample chambers adapted to receive sample liquids,

a pipette frame mounted vertically on said base above

said carriage and said sample plate, said pipette frame having vertical mounting posts separated longitudinally from each other, each of said posts secured to said base,

a mounting plate assembly slidably guided by said posts and disposed laterally with respect to said sample plate and including,

a mounting plate having slidable guides disposed about said posts,

a barrel bar fixed to said mounting plate,

a plurality of microsyringe barrels having their heads secured in a row in said barrel bar and spaced corresponding to the spacing of said liquid chambers on said plate, said barrels being hollow with each having a lower tip,

a plunger bar vertically movably disposed above said barrel bar and having a plurality of microplungers secured thereto, each of said microplungers movably disposed within a corresponding microsyringe barrel, and

a plunger actuator plate vertically movable with respect to said mounting plate and carried by said mounting plate, said actuator plate removably secured to said plunger bar,

translation and signalling means for moving said carriage longitudinally forward beneath said mounting plate assembly and generating carriage position signals indicative of said carriage position,

moving said mounting plate assembly vertically with respect to said base and generating mounting plate position signals indicative of mounting plate position, and

moving said plunger actuator bar and said plunger bar vertically with respect to said mounting plate and generating plunger bar position signals indicative of plunger bar position, and

programmed computer means responsive to said carriage position signals, to said mounting plate position signals and to said plunger bar position signals for generating a sequence of control signals to said translation means for translating said carriage, said mounting plate and said plunger bar to aspirate a first predetermined amount of liquid from said sample chambers into said respective pipette barrels, and to apply a droplet of said liquid samples in each of said pipette barrels onto corresponding spaces of said microporous support medium when placed on said lateral application space of said sample plate by precisely positioning said lower tips of said barrels at a small distance above said microporous support medium, said small distance being smaller than the diameter of a droplet of liquid sample which may be maintained on the end of said tips through surface tension forces of the barrel tips, whereby each droplet slightly touches said microporous support medium and is thereby relieved of its surface tension and is precisely transferred to said microporous support medium from each of said pipette barrels.

15. The apparatus of claim 14 wherein said sample plate includes a wash well and a waste well longitudinally spaced from each other and from said sample chambers,

said programmed computer means generating a further sequence of control signals to said translation means before aspirating liquid from said sample chambers,

to draw a second predetermined amount of rinse liquid from said wash well into respective pipette barrels, and

to discharge said rinse liquid into said waste well.

16. The apparatus of claim 14 wherein said translation and signalling means comprises,

carriage translation means responsive to carriage translative signals for longitudinally translating said carriage and said sample plate on said track means beneath said pipette assembly for operably translating said plate to at least a sample chamber position where said sample chambers are beneath said microsyringe barrels and to an application position where said microporous support medium is beneath said microsyringe barrels,

carriage signalling means for generating a sample chamber carriage position signal when said sample chambers are beneath said microsyringe barrels, and an application position signal where said microporous support medium is beneath said microsyringe barrels,

mounting plate assembly translating means responsive to up and down mounting plate assembly translation signals for vertically translating said mounting plate assembly between an upper position and a lower position, said upper position being sufficiently high to lift said microsyringe barrels above said plate operably allowing translation of said plate beneath said barrels, said lower position operably allowing insertion of said barrels into said fluid sample chambers when said plate is in said sample chamber position and operably allowing said barrels to be slightly above said microporous support medium when secured to said lateral application space of said plate,

mounting plate signalling means for generating a mounting plate upper position signal when said mounting plate is in said upper position and a mounting plate lower position signal when said mounting plate is in said lower position,

plunger actuator plate translating means responsive to up and down plunger actuator plate translation signals for vertically translating said plunger actuator plate and said plunger bar between a lower position where said microplungers are fully within said corresponding microsyringe barrels to a sample upper position where said microplungers are extended upwardly through said barrels operably drawing fluid into said barrels when said tips are immersed in fluid in said sample chamber,

plunger actuator plate signalling means for generating a plunger bar lower position signal when said plunger actuator plate and said plunger bar are in said lower position, and a plunger bar sample upper position signal when said plunger actuator plate and said plunger bar are in said sample upper position, and

electrical means for providing signal communication between said programmed digital computer and said carriage translation means, said mounting plate assembly translating means, and said plunger actuator plate translating means, and for providing signal communication between said digital computer and

said carriage signalling means, said mounting plate signalling means, and said plunger actuator plate signalling means.

17. The apparatus of claim 16 wherein said digital

computer means includes a stored sequence of instructions for

generating and applying said carriage translation signal to said carriage translation means thereby translating said carriage to said sample chamber position and removing said carriage translation signal when said sample chamber carriage position signal is received,

said programmed digital computer means operably generating and applying said down mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said upper position to said lower position and removing said mounting plate assembly translation signal when said mounting plate lower position signal is received,

said programmed digital computer means operably generating and applying said up plunger actuator plate translation signal to said plunger actuator plate translating means thereby translating said plungers from said lower position to said sample upper position and removing said plunger actuator plate translation signal when said plunger bar sample upper position signal is received, operably causing fluid in each of said sample chambers to be aspirated into said corresponding barrels,

said programmed digital computer means operably generating and applying said up mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said lower position to said upper position and removing said mounting plate assembly translation signal when said mounting plate upper position signal is received,

said programmed digital computer means operably generating and applying said carriage translation signal to said carriage translation means thereby translating said carriage to said application position and removing said carriage translation signal when said application carriage position signal is received,

said programmed digital computer means operably generating and applying said down mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said upper position to said lower position and removing said mounting plate assembly translation signal when said mounting plate lower position signal is received, and

said programmed digital computer means operably generating and applying said down plunger actuator plate translation signal to said plunger actuator plate translating means thereby translating said plunger from said sample upper position to said lower position and removing said plunger actuator plate translation signal when said plunger bar sample lower position signal is received, operably causing fluid in each of said barrels to be applied to said microporous support medium when secured to said lateral application space of said plate.

18. The apparatus of claim 17 wherein said sample plate further includes

a wash well and a waste well longitudinally spaced from each other and from said sample chambers, and

said plunger actuator plate translating means further includes a wash upper position, and

said plunger actuator plate signalling means further includes means for generating a plunger bar wash

upper position signal when said plunger actuator plate and said plunger bar are in said wash upper position,

said carriage translation means further includes a wash well position and a rinse well position, and said carriage signalling means further includes means for generating a wash well carriage position signal when said wash well is beneath said microsyringe barrels and a waste well carriage position signal when said waste well is beneath said microsyringe barrels,

said digital computer means includes a further stored sequence of instructions for before aspirating liquid from said sample chambers,

generating and applying said carriage translation signal to said carriage translation means thereby translating said carriage to said wash well position and removing said carriage translation signal when said wash well carriage position signal is received,

said programmed digital computer means operably generating and applying said down mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said upper position to said lower position and removing said mounting plate assembly translation signal when said mounting plate lower position signal is received,

said programmed digital computer means operably generating and applying said up plunger actuator plate translation signal to said plunger actuator plate translating means thereby translating said plungers from said lower position to said wash upper position and removing said plunger actuator plate translation signal when said plunger bar wash upper position signal is received, operably causing fluid in said wash well to be aspirated into said barrels,

said programmed digital computer means operably generating and applying said up mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said lower position to said upper position and removing said mounting plate assembly translation signal when said mounting plate upper position signal is received,

said programmed digital computer means operably generating and applying said carriage translation signal to said carriage translation means thereby translating said carriage to said wash well position and removing said carriage translation signal when said wash well carriage position signal is received,

said programmed digital computer means operably generating and applying said down mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said upper position to said lower position and removing said mounting plate assembly translation signal when said mounting plate lower position signal is received,

said programmed digital computer means operably generating and applying said down plunger actuator plate translation signal to said plunger actuator plate translating means thereby translating said plunger from said wash upper position to said lower position and removing said plunger actuator plate translation signal when said plunger bar lower position signal is received, operably causing

fluid in each of said barrels to be applied to said waste well, and

said programmed digital computer means operably generating and applying said up mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said lower position to said upper position and removing said mounting plate assembly translation signal when said mounting plate upper position signal is received.

19. The apparatus of claim 14 wherein said means for translating said carriage longitudinally forward and backward beneath said mounting plate assembly comprises

a carriage actuating motor fixed to said base, said motor having a rotatable output shaft,  
a pinion gear fixed to said output shaft,  
a rack gear secured to said carriage, said rack gear being in engagement with said pinion gear whereby the output shaft turning of said motor translates said carriage.

20. The apparatus of claim 14 wherein said means for translating said mounting plate assembly up and down with respect to said base comprises

a mounting plate actuator motor fixed to said mounting plate, said motor having a rotatable output shaft,

pinion gear means fixed to said output shaft,

a rack gear secured to said base, said rack gear being in engagement with said pinion gear means whereby the output shaft turning of said mounting plate actuator motor translates said mounting plate up or down with respect to said base.

21. The apparatus of claim 14 wherein said signalling means for generating mounting plate position signals indicative of mounting plate position includes

upper stop means secured to a member secured to said base,

upper trip switch means secured to said mounting plate and having a trip arm for engaging said upper stop means for operatively tripping said upper trip switch means when said mounting plate reaches its upper limit of travel,

lower stop means secured to said base, and

lower trip switch means secured to said mounting plate having a trip arm for engaging said lower stop means for operatively tripping said lower trip switch means when said mounting plate reaches its lower limit of travel.

22. The apparatus of claim 14 wherein said sample plate means further includes a row of individual liquid dilution wells longitudinally spaced from said sample chambers, said diluted wells adapted to receive dilution liquid,

said programmed computer means generating a further sequence of control signals to said longitudinal translation means, to said vertical translation means and to said translation signalling means for moving said plunger actuator bar and said plunger bar vertically with respect to said mounting plate for applying said first predetermined amount of liquid sample in each barrel to said dilution wells, applying a third predetermined amount of wash liquid from each barrel to said dilution wells, mixing the combination of said wash liquid and said liquid sample of said dilution wells, and aspirating an

amount of diluted liquid samples from said dilution wells into said respective pipette barrels.

23. Automatic pipetting apparatus comprising, a base,

track means disposed longitudinally on said base, a carriage longitudinally movably disposed on said track means,

a sample plate removably disposed on said carriage, said sample plate including a lateral row of individual liquid sample chambers and a lateral application space longitudinally separated from said liquid chamber row, said lateral application space adapted to receive a microporous support medium, said sample chambers adapted to receive sample liquids,

a pipette frame mounted vertically on said base above said carriage and said sample plate, said pipette frame having vertical mounting posts separated longitudinally from each other, each of said posts secured to said base,

a mounting plate assembly slidably guided by said posts and disposed laterally with respect to said sample plate and including,

a mounting plate having slidable guides disposed about said posts,

a barrel bar fixed to said mounting plate,

a plurality of microsyringe barrels having their heads secured in a row of said barrel bar and spaced corresponding to the spacing of said liquid chambers on said plate, said barrels being hollow with each having a lower tip,

a plunger bar vertically movably disposed above said barrel bar and having a plurality of microplungers secured thereto, each of said microplungers movably disposed within a corresponding barrel of said microsyringes, and

a plunger actuator plate vertically movable with respect to said mounting plate and carried by said mounting plate, said actuator plate removably secured to said plunger bar,

translation and signalling means for

moving said carriage longitudinally forward beneath said mounting plate assembly and generating carriage position signals indicative of said carriage position,

moving said mounting plate assembly vertically with respect to said base and generating mounting plate position signals indicative of mounting plate position, and

moving said plunger actuator bar and said plunger bar vertically with respect to said mounting plate and generating plunger bar position signals indicative of plunger bar position, and

programmed computer means responsive to said carriage position signals, to said mounting plate position signals and to said plunger bar position signals for generating a sequence of control signals to said translation means for translating said carriage, said mounting plate and said plunger bar to aspirate a first predetermined amount of liquid from said sample chambers into said respective pipette barrels, and to apply said liquid in each of said pipette barrels from a position slightly above said microporous support medium whereby droplets of said liquid which forms on the tops of said barrels are transferred from said tips onto corresponding spaces of said microporous support medium when

placed on said lateral application space of said sample plate, and

wherein said sample plate includes a wash well and a waste well longitudinally spaced from each other and from said sample chambers,

said programmed computer means generating a further sequence of control signals to said translation means before aspirating liquid from said sample chambers,

to draw a second predetermined amount of rinse liquid from said wash well into respective pipette barrels, and

to discharge said rinse liquid into said waste well and wherein said sample plane includes a longitudinal blotting space for applying a lateral blotting paper strip, said blotting space longitudinally separated from said sample chamber row, said wash well, said waste well and said lateral application space, and

said programmed computer means generating a further sequence of control signals to said translation means after discharging said rinse liquid into said waste well,

to blot the tips of said barrels on said blotting paper strip.

24. The apparatus of claim 23 wherein said sample plate includes a raised portion and a lower portion, said row of individual liquid sample chambers, said wash well and said waste well being disposed on said raised portion, said lateral application space and said blotting space being disposed on said lower portion.

25. The apparatus of claim 23 wherein said sample plate includes a raised portion and a lower portion, said row of individual liquid sample chambers being disposed on said raised portion, said lateral application space being disposed on said lower portion.

26. The apparatus of claim 25 wherein said signalling means for generating carriage position signals indicative of carriage position includes

said carriage having a first longitudinal surface with notches disposed thereon, the longitudinal separation of said notches corresponding to the longitudinal position of said wash well, said waste well, said longitudinal blotting space, said sample chambers and said lateral application space,

a first trip switch secured to said track means on which said carriage moves, said switch having a first spring forced roller means for engaging said longitudinal surface whereby said switch is tripped when said roller is forced into a notch, operatively indicating that said wash well or said waste well or said longitudinal blotting space, or said sample chambers, or said lateral application space is beneath said microsyringe barrels.

27. The apparatus of claim 26 wherein said signalling means for generating carriage position signals indicative of carriage position includes

said carriage having a second longitudinal surface with at least one notch disposed thereon near the forward end of said carriage,

a second trip switch secured to said track on which said carriage moves, said second switch having a second spring forced roller means for engaging said second longitudinal surface whereby said switch is tripped when said second roller means is forced into said notch operatively indicating that said carriage has reached its rearward limit of travel.

28. The apparatus of claim 27 further comprising a limit switch means secured to the rear of said carriage at a position for engaging the forward end of said plate for indicating that said plate is in an operative position within said carriage.

29. The apparatus of claim 25 wherein said means for translating said plunger bar up and down with respect to said mounting plate comprises

a plunger plate motor fixed to said mounting plate, said motor having a rotatable output shaft, pinion gear means fixed to said output shaft, rack gear means fixed to said plunger actuator plate, said rack gear being in engagement with said pinion gear means whereby the output shaft turning of said plunger actuator plate motor translates said actuator plate and said plunger bar up or down with respect to said mounting plate.

30. The apparatus of claim 29 wherein said plunger actuator plate motor is fixed to the rear side of said mounting plate,

said mounting plate includes two vertically plunger actuator plate guides with vertical grooves provided therein, said guides being fixed to the forward side of said mounting plate,

said plunger actuator plate is slidingly disposed within said vertical grooves on said mounting plate,

said mounting plate has vertical slots therein, and said rack gear means fixed to said plunger actuator plate extend from said plunger actuator plate on the forward side of said mounting plate to said pinion gear means fixed to said output shaft of said plunger actuator plate motor on the rear side of said mounting plate.

31. The apparatus of claim 29 wherein said signalling means for generating plunger bar position signals indicative of plunger bar position includes

application cam means vertically adjustable on a vertical shaft secured to said plunger actuator plate, wash cam means vertically adjustable on a vertical shaft secured to said plunger actuator plate,

a first trip switch means secured to said mounting plate and having a trip arm for engaging said application cam means for operatively tripping said first trip switch means when said plunger actuator plate reaches an upper application position, and operatively tripping said first trip switch means when said plunger actuator plate reaches an upper wash position,

lower cam means vertically adjustable on a vertical shaft secured to said plunger actuator plate, and a second trip switch means secured to said mounting plate and having a trip arm for engaging said down cam means for operatively tripping said second trip means when said plunger actuator plate reaches its lower limit of travel.

32. Automatic pipetting apparatus comprising,

a base, track means disposed longitudinally on said base, a carriage longitudinally movably disposed on said track means,

a sample plate removably disposed on said carriage, said sample plate including a lateral row of individual liquid sample chambers and a lateral application space longitudinally separated from said liquid chamber row, said lateral application space adapted to receive a microporous support medium, said sample chambers adapted to receive sample liquids,

a pipette frame mounted vertically on said base above said carriage and said sample plate, said pipette frame having vertical mounting posts separated longitudinally from each other, each of said posts secured to said base, 5

a mounting plate assembly slidably guided by said posts and disposed laterally with respect to said sample plate and including, 5

a mounting plate having slidable guides disposed about said posts, 10

a barrel bar fixed to said mounting plate, 10

a plurality of microsyringe barrels having their heads secured in a row in said barrel bar and spaced corresponding to the spacing of said liquid chambers on said plate, said barrels being hollow with each having a lower tip, 15

a plunger bar vertically movably disposed above said barrel bar and having a plurality of microplungers secured thereto, each of said microplungers movably disposed within a corresponding barrel of said microsyringes, and 20

a plunger actuator plate vertically movable with respect to said mounting plate and carried by said mounting plate, said actuator plate removably secured to said plunger bar, 25

translation and signalling means for moving said carriage longitudinally forward beneath said mounting plate assembly and generating carriage position signals indicative of said carriage position, 30

moving said mounting plate assembly vertically with respect to said base and generating mounting plate position signals indicative of mounting plate position, and

moving said plunger actuator bar and said plunger bar vertically with respect to said mounting plate and generating plunger bar position signals indicative of plunger bar position, and 35

programmed computer means responsive to said carriage position signals, to said mounting plate position signals and to said plunger bar position signals for generating a sequence of control signals to said translation means for translating said carriage, said mounting plate and said plunger bar to aspirate a first predetermined amount of liquid from said sample chambers into said respective pipette barrels, and to apply said liquid in each of said pipette barrels from a position slightly above said microporous support medium whereby droplets of said liquid which forms on the tops of said barrels are transferred from said tips onto corresponding spaces of said microporous support medium when placed on said lateral application space of said sample plate, 50

wherein said translation and signalling means comprises, 55

carriage translation means responsive to carriage translative signals for longitudinally translating said carriage and said sample plate on said track means beneath said pipette assembly for operably translating said plate to at least a sample chamber position where said sample chambers are beneath said microsyringe barrels and to an application position where said microporous support medium is beneath said microsyringe barrels, 60

carriage signalling means for generating a sample chamber carriage position signal when said sample chambers are beneath said microsyringe barrels, 65

and an application position signal where said microporous support medium is beneath said microsyringe barrels,

mounting plate assembly translating means responsive to up and down mounting plate assembly translation signals for vertically translating said mounting plate assembly between an upper position and a lower position, said upper position being sufficiently high to lift said microsyringe barrels above said plate operably allowing translation of said plate beneath said barrels, said lower position operably allowing insertion of said barrels into said fluid sample chambers when said plate is in said sample chamber position and operably allowing said barrels to be slightly above said microporous support medium when secured to said lateral application space of said plate,

mounting plate signalling means for generating a mounting plate upper position signal when said mounting plate is in said upper position and a mounting plate lower position signal when said mounting plate is in said lower position,

plunger actuator plate translating means responsive to up and down plunger actuator plate translation signals for vertically translating said plunger actuator plate and said plunger bar between a lower position where said microplungers are fully within said corresponding microsyringe barrels to a sample upper position where said microplungers are extended upwardly through said barrels operably drawing fluid into said barrels when said tips are immersed in fluid in said sample chamber,

plunger actuator plate signalling means for generating a plunger bar lower position signal when said plunger actuator plate and said plunger bar are in said lower position, and a plunger bar sample upper position signal when said plunger actuator plate and said plunger bar are in said sample upper position, and

electrical means for providing signal communication between said programmed digital computer and said carriage translation means, said mounting plate assembly translating means, said plunger actuator plate translating means, and for providing signal communication between said digital computer and

said carriage signalling means, said mounting plate signalling means, and said plunger actuator plate signalling means, wherein said digital computer means includes a stored sequence of instructions for generating and applying said carriage translation signal to said carriage translation means thereby translating said carriage to said sample chamber position and removing said carriage translation signal when said sample chamber carriage position signal is received,

said programmed digital computer means operably generating and applying said down mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said upper position and said lower position and removing said mounting plate assembly translation signal when said mounting plate lower position signal is received,

said programmed digital computer means operably generating and applying said up plunger actuator plate translation signal to said plunger actuator

plate translating means thereby translating said plungers from said lower position to said sample upper position and removing said plunger actuator plate translation signal when said plunger bar sample upper position signal is received, operably causing fluid in each of said sample chambers to be aspirated into said corresponding barrels, 5

said programmed digital computer means operably generating and applying said up mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said lower position to said upper position and removing said mounting plate assembly translation signal when said mounting plate upper position signal is received, 10 15

said programmed digital computer means operably generating and applying said carriage translation signal to said carriage translation means thereby translating said carriage to said application position and removing said carriage translation signal when said application carriage position signal is received, 20

said programmed digital computer means operably generating and applying said down mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said upper position to said lower position and removing said mounting plate assembly translation signal when said mounting plate lower position signal is received, and 25 30

said programmed digital computer means operably generating and applying said down plunger actuator plate translation signal to said plunger actuator plate translating means thereby translating said plunger from said sample upper position to said lower position and removing said plunger actuator plate translation signal when said plunger bar sample lower position signal is received, operably causing fluid in each of said barrels to be applied to said microporous support medium when secured to said lateral application space of said plate, 35 40

wherein said sample plate further includes a wash well and a waste well longitudinally spaced from each other and from said sample chambers, and

said plunger actuator plate translating means further includes a wash upper position, and 45

said plunger actuator plate signalling means further includes means for generating a plunger bar wash upper position signal when said plunger actuator plate and said plunger bar are in said wash upper position, 50

said carriage translation means further includes a wash well position and a rinse well position, and said carriage signalling means further includes means for generating a wash well carriage position signal when said wash well is beneath said microsyringe barrels and a waste well carriage position signal when said waste well is beneath said microsyringe barrels, 55

said digital computer means includes a further stored sequence of instructions for before aspirating liquid from said sample chambers, 60

generating and applying said carriage translation signal to said carriage translation means thereby translating said carriage to said wash well position and removing said carriage translation signal when said wash well carriage position signal is received, 65

said programmed digital computer means operably generating and applying said down mounting plate

assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said upper position to said lower position and removing said mounting plate assembly translation signal when said mounting plate lower position signal is received,

said programmed digital computer means operably generating and applying said up plunger actuator plate translation signal to said plunger actuator plate translating means thereby translating said plungers from said lower position to said wash upper position and removing said plunger actuator plate translation signal when said plunger bar wash upper position signal is received, operably causing fluid in said wash well to be aspirated into said barrels,

said programmed digital computer means operably generating and applying said up mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said lower position to said upper position and removing said mounting plate assembly translation signal when said mounting plate upper position signal is received,

said programmed digital computer means operably generating and applying said carriage translation signal to said carriage translation means thereby translating said carriage to said wash well position and removing said carriage translation signal when said wash well carriage position signal is received,

said programmed digital computer means operably generating and applying said down mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said upper position to said lower position and removing said mounting plate assembly translation signal when said mounting plate lower position signal is received,

said programmed digital computer means operably generating and applying said down plunger actuator plate translation signal to said plunger actuator plate translating means thereby translating said plunger from said wash upper position to said lower position and removing said plunger actuator plate translation signal when said plunger bar lower position signal is received, operably causing fluid in each of said barrels to be applied to said waste well, and

said programmed digital computer means operably generating and applying said up mounting plate assembly translation signal to said mounting plate assembly translating means thereby translating said mounting plate assembly from said lower position to said upper position and removing said mounting plate assembly translation signal when said mounting plate upper position signal is received, and wherein

said sample plate further includes a blotting space for applying a lateral blotting paper strip, said blotting space longitudinally separated from said sample chamber row, said wash well, said waste well and said lateral application space,

said carriage translation means further includes a blotting position, and

said carriage signalling means further includes means for generating a blotting carriage position signal when said blotting space is beneath said microsyringe barrels,



said digital computer means includes a further stored  
sequence of instructions for after discharging said  
rinse liquid to said waste well,  
generating and applying said carriage translation  
signal to said carriage translation means thereby  
translating said carriage to said blotting position  
and removing said carriage translation signal when  
said blotting carriage position is received,  
said programmed digital computer means operably  
generating and applying said down mounting plate  
assembly translation signal to said mounting plate  
assembly translating means thereby translating said  
mounting plate assembly from said upper position  
to said lower position and removing said mounting  
plate assembly translation signal when said mount-

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ing plate lower position signal is received, whereby  
said barrel tips are blotted when said blotting paper  
is disposed on said blotting space, and  
said digital computer means includes a further stored  
sequence of instructions for  
said programmed digital computer means operably  
generating and applying said up mounting plate  
assembly translation signal to said mounting plate  
assembly translating means thereby translating said  
mounting plate assembly from said lower position  
to said upper position and removing said mounting  
plate assembly translation signal when said mount-  
ing plate upper position signal is received.

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